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EDITOR'S OUTLOOK

Many fine occasions are being arranged for the Baltimore Spring Meeting of the Division of Chemical Education of the A. C. S. Make plans to come!

The Secretary of the Division, Dr. B. S. Hopkins reports that the program is well advanced and that he is aiming to make a full announcement in the March issue of THIS JOURNAL. The present outlook is that there will be, at least, two symposiums where authorities will bring their contributions for help and inspiration to you and me. If you have any contribution which you feel will be helpful to your co-workers, send it at once to Dr. Hopkins, University of Illinois, Urbana, Ill.

Special preparations are being made to have teachers meet each other in order that they may become better acquainted, for it is an established fact that from the exchanging of ideas there results an exaltation not to be derived from books, papers or by facing our task alone. At one of the Divisional meetings or at one of the social gatherings a picture is being planned for the entire membership in order that you may carry your acquired acquaintanceship home in a more remindful form.

The contacts which you will make are sure to give you, sooner or later, high returns. It is really a tragedy for a man to lose his position without some contact with his co-workers. Likewise, promotion depends, directly or indirectly, upon the contacts which you have made with the teachers outside of your own department. You must be definitely identified with your cause and be willing to spend and be spent in your own improvement and that of others if you are to surge ahead in your chosen field.

THOMAS PAINE'S THEORY OF ATMOSPHERIC CONTAGION AND HIS ACCOUNT OF AN EXPERIMENT PERFORMED BY GEORGE WASHINGTON UPON THE PRODUCTION OF MARSH GAS*

C. A. BROWNE, CHIEF OF THE BUREAU OF CHEMISTRY, WASHINGTON, D. C.

In looking up the literature upon the early chemical theories concerning contagious diseases, the writer discovered an interesting report which bore the title "Of the Cause of Yellow Fever and the Means of Preventing It in Places Not Yet Infected with It; addressed to the Board of Health in America. By Thomas Paine."

The celebrity of Thomas Paine, as an advocate of American Independence and as an author of works upon politics and religion, has apparently so overshadowed his reputation as a writer on scientific subjects, that his report upon yellow fever is no longer generally mentioned. Paine's theory of yellow fever had something in common with those held by Alexander von Humboldt and Dr. Samuel Latham Mitchill, all three of whom believed the disease to be produced by noxious emanations from decaying organic matter.

Humboldt, in his "Personal Narrative of Travels to the Equinoctial Regions of America,"[1] makes the frequent statement that the contagious principle of yellow fever is a ternary or quarternary combination of nitrogen, phosphorus, hydrogen, carbon and sulphur. He supposed mangrove trees to be especially productive of miasmatic exhalations because of their tannin content, although the connection is not explained. The heating by the tropical sun of the humid roots of the mangroves, he thought might start a fermentation in the wet leaves, mollusks, and other decaying organic matter which would lead to the production of deleterious gases. Humboldt in one experiment exposed the wet wood and roots of the mangrove to the action of air in a glass-stoppered bottle. The whole of the oxygen disappeared with a diminution of the volume of air exceeding that of the oxygen absorbed, and this led him to attribute the vitiations of the air to the mangrove. He writes:

> The more I reflect upon this subject the more mysterious appears to me all that relates to those gaseous emanations which we call so vaguely the seeds of contagion and which are supposed to be developed by a corrupted air, destroyed by cold, conveyed from place to place in garments and attached to the walls of homes.

Dr. Samuel Latham Mitchill,[2] a distinguished New York chemist

* Paper read before the History of Chemistry Section at the New Haven meeting of the American Chemical Society, 1923.

[1] Translation of Thomasina Ross, London, 1900, vol. 1, pages 286, 287, 372, etc.

[2] For the views of Dr. Mitchill upon septon (nitrogen), septous gas, septic acid, etc., with reference to contagious diseases, see his numerous articles in Vol. II of the Medical Repository. See also the address of Dr. Edgar F. Smith upon Samuel Latham Mitchill, *Jour. Ind. and Eng. Chem.*, **14**, 559 (1922).

and physician of a century ago, believed the miasma of yellow fever to be an oxide of nitrogen (which he called septous gas) that could be absorbed by lime, advancing as an argument for this the observation "that the healthiest parts of a country were usually of calcareous formations." Humboldt, as an advocate of the ternary combination idea of contagion, was not very favorably disposed to the septous gas theory of Mitchill. He writes:

Whatever idea may be formed of the miasmata which occasion the insalubrity of the air, it appears very improbable according to the present state of our chemical knowledge, that ternary or quaternary combinations of phosphorus, hydrogen, azote, and sulphur, can be absorbed by lime, and particularly by the carbonate of lime. Such, however, has been the political influence of the theories of M. Mitchill, in a country where the wisdom of the magistrates is very justly admired, that while I was at quarantine in the Delaware, on arriving from the West Indies at Philadelphia, I saw officers of the committee of Health, gravely cause the opening of the hatchway to be painted with water of lime, that the *septon* or miasma of the yellow fever of the Havannah which they supposed to exist in our vessel, should fix itself on a band of lime of three decimeters (about a foot) in breadth. Was it at all surprising that our Spanish sailors thought there was something magical in this pretended means of disinfection?

Thomas Paine differed from both Humboldt and Mitchill in that he considered the pernicious miasma of yellow fever to be marsh gas. His theory like theirs now belongs to the forgotten collection of scientific vagaries and his report to the Board of Health in America might be dismissed with a bare mention except for the fact that it describes an interesting chemical experiment that was once carried out by George Washington. The account is one which deserves to be recorded in the annals of American Chemistry and is reproduced as follows:

The muddy bottom of rivers contains great quantities of impure, and often inflammable air (carburetted hydrogen gas), injurious to life; and which remains entangled in the mud till let loose from thence by some accident. This air is produced by the dissolution and decomposition of any combustible matter falling into the water, and sinking into the mud, of which the following circumstance will serve to give some explanation.

In the fall of the year that New York was evacuated (1783), General Washington had his headquarters at Mrs. Berrian's, at Rocky-Hill, in Jersey, and I was there. The Congress then sat at Princeton. We had several times been told that the river or creek that runs near the bottom of Rocky Hill, and over which there is a mill, might be set on fire, for that was the term the country people used, and as General Washington had a mind to try the experiment, General Lincoln, who was also there, undertook to make preparation for it against the next evening, Nov. 5th. This was to be done, as we were told, by disturbing the mud at the bottom of the river, and holding something in a blaze, as paper or straw, a little above the surface of the water.

Cols. Humphries and Cob were at that time aid-de-camps of Gen. Washington, and these two gentlemen and myself got into an argument respecting the cause. Their opinion was that, on disturbing the bottom of the river, some bituminous matter arose to the surface, which took fire when the light was put to it. I, on the contrary, supposed that a quantity of inflammable air was let loose, which ascended through the water and took fire above the surface. Each party held to his opinion, and the next evening the experiment was to be made.

A scow had been stationed in the mill-dam, and Gen. Washington, Gen. Lincoln, and myself, and I believe Col. Cob (for Col. Humphries was sick), and 3 or 4 soldiers with poles, were put on board the scow. Gen Washington placed himself at one end of the scow, and I at the other. Each of us had a roll of cartridge paper, which we lighted and held over the water, about 2 or 3 inches from the surface, when the soldiers began disturbing the bottom of the river with the poles.

As Gen. Washington sat at one end of the scow, and I at the other, I could see better anything that might happen from his light, than I could from my own, over which I was nearly perpendicular. When the mud at the bottom was disturbed by the poles, the air bubbles rose fast, and I saw the fire take from Gen. Washington's light, and descend from thence to the surface of the water, in a similar manner as when a lighted candle is held so as to touch the smoke of a candle just blown out, the smoke will take fire, and the fire will descend and light up the candle. This was demonstrative evidence, that what was called setting the river on fire, was setting the inflammable air on fire that arose out of the mud.

I mentioned this experiment to Mr. Rittenhouse, of Philadelphia, the next time I went to that city, and our opinion on the case was that the vapor that issued from any combustible matter (vegetable or otherwise) that underwent a dissolution and decomposition of its parts, either by fire or water in a confined place, so as not to blaze would be inflammable, and would become flame whenever it came in contact with flame.

In order to determine if this was the case, we filled up the breach of a gun barrel about 5 or 6 inches with sawdust and the upper part with dry sand to the top, and, after spiking up the touch hole, put the breach into a smith's furnace and kept it red hot, so as to consume the sawdust; the sand, of consequence, would prevent any blaze. We applied a lighted candle to the mouth of the barrel; as the first vapor that flew off would be humid, it extinguished the candle; but, after applying the candle three or four times, the vapor that issued out began to flash. We then tied a bladder over the mouth of the barrel, which the vapor soon filled, and then, tying a string round the neck of the bladder, above the muzzle, took the bladder off.

As we could not conveniently make experiments upon the vapor while it was in the bladder, the next operation was to get it into a phial; for this purpose, we took a phial of about 3 or 4 ounces, filled it with water, put a cork slightly into it, and, introducing it into the neck of the bladder, worked the cork out, by getting hold of it through the bladder, into which the water then emptied itself, and the air in the bladder, ascended into the phial; we then put the cork into the phial, and took it from the bladder. It was now in a convenient condition for experiment.

We put a lighted match into the phial, and the air or vapor in it blazed up in the manner of a chimney on fire. We extinguished it 2 or 3 times, by stopping the mouth of the phial; and putting the lighted match to it again, it repeatedly took fire, till the vapor was spent, and the phial became filled with atmospheric air.

These two experiments, that, in which some combustible substance (branches and leaves of trees) had been decomposed by water, in the mud; and this, where the decomposition had been produced by fire, without blazing, show, that a species of air injurious to life, when taken into the lungs, may be generated from substances which in themselves are harmless.

THE EFFECTS OF DIFFERENT INSTRUCTORS FOR RECITATION AND LABORATORY IN FRESHMAN CHEMISTRY

F. E. BROWN AND KENNETH L. BIRD, IOWA STATE COLLEGE, AMES, IOWA

The difficulties of a college freshman in chemistry are many. Some are real, others are fancied. Some are inevitable and others are avoidable. Some are recognized, others are unrecognized.

One of the only half recognized, partially avoidable, real difficulties is a system which gives to a freshman one teacher to hear his recitation and a second to direct his laboratory work, besides his lecturer. These three may use different methods of instruction, or even different nomenclature, on some occasions.

Many schools are using this system. Some make no effort to secure for their pupils the same instructor in recitation and laboratory. The complexity of schedules makes it highly improbable that such a result will be obtained unless a special effort is made. So far as we know no actual test has been made to determine the effect of this system.

For several years our professors have believed that a better acquaintance between teacher and pupil was extremely desirable, and that a decrease in the number of instructors to whom each pupil was to recite would promote a better attitude and better work on the part of the pupils. At the expense of a great deal of preliminary work we have arranged our class work and laboratory work so that as many students as possible meet the same instructor in recitation and laboratory. During the last three years students have been enrolled under one professor for about 13,000 quarter-credits in freshman chemistry. Of these more than 1000 have either failed to seriously start their work or have been excused from completing their work on account of illness. Those who seriously started numbered 11,723. Of these 3986 were so assigned that they met the same teacher in recitation as in laboratory, 7637 met different teachers in recitation and laboratory.

Recently an analysis of results was made. There are at least three measurable results which are interesting: (*a*) the distribution between the two groups of pupils who dropped the course before the end of the quarter, (*b*) a comparison of the final grades made by the members of the two groups, and (*c*) a comparison of the grades in written work given by the lecturer, made by members of the two groups.

The separation of those who dropped too early to consider, from those who are to be considered as affected by the system was difficult. Assignments to teach particular sections in laboratory are not considered permanent until the second week of school No pupil who failed to report to his laboratory section after the permanent instructor began meeting it, is included in the 11,723 students.

The final grade which a pupil receives for a quarter's work, is given by

the recitation instructor. That instructor has before him a card filled out by the freshman chemistry office for each of his pupils on which is recorded, (*a*) his own estimate of the pupils work in recitation sent in at intervals of two weeks, (*b*) a similar report from the laboratory instructor, (*c*) the grades for all lecture tests, (*d*) the final examination grade and, (*e*) a similar report of all previous quarter's work in freshman

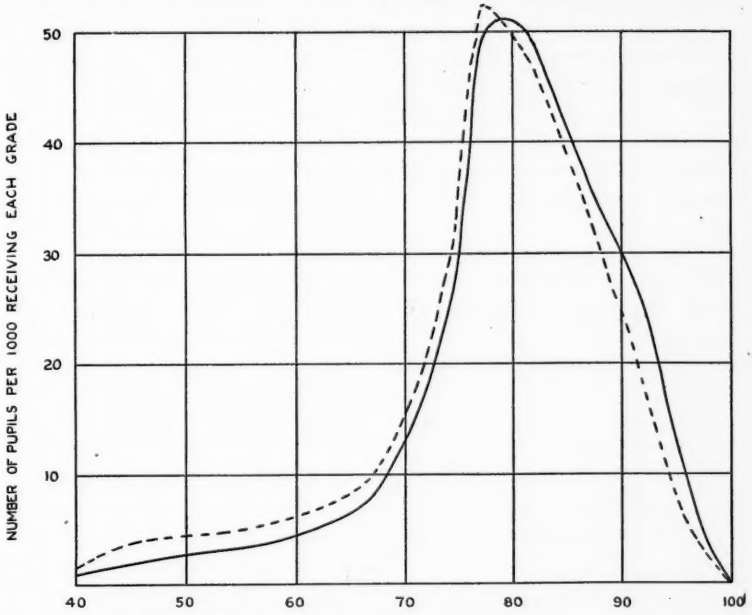


FIG. 1

THE SOLID LINE REPRESENTS PUPILS HAVING THE SAME INSTRUCTOR IN RECITATION AND LABORATORY: THE BROKEN LINE, PUPILS HAVING DIFFERENT INSTRUCTORS.

chemistry. However, the instructor is not bound to follow exact averages and might let a closer acquaintance, such as would be formed in laboratory, unconsciously, affect the final grade reported.

The tests and final examinations are given by the lecturer. The questions are as completely unknown to the instructors as to the pupils themselves. The answers are graded by squads of instructors each of whom grades one answer in all books. The Professor who wrote the questions discusses the grading of the answers with the squad and frequently acts as the squad leader and grades one question. The instructor affects the grades of his pupils in written work only by the quality of his teaching. There is only one serious objection to judging the effect of having the same instructor in recitation and laboratory, or of having different in-

structors, solely by the written work. This is the fact, that the professors frequently teach recitation sections and never teach laboratory sections. Several hundred of the pupils listed as having different instructors in recitation and laboratory were meeting in recitation the professor who prepared the questions in tests and final examinations for them. No pupil listed as having the same instructor in recitation and laboratory had this advantage.

Of the 3986 who had the same teacher in recitation and laboratory 169 or 4.4% dropped before the quarter ended. Of the 7637 who had different instructors in recitation and laboratory, 419 or 5.6% dropped before the end of the quarter. This left 11,035 pupils who completed their quarter's work with 3817 having the same instructor and 7218 having different instructors. The distribution of grades for this 11,035 is given in tables I and II.

TABLE I

GENERAL EFFECT OF A CHANGE OF INSTRUCTIONS ON GRADES

Grades in Per cent	Tests	Examinations	Quarter grade
Below 60	Same 11.5	16.7	5.6
	Diff. 14.6	19.5	8.3
60–74	Same 27.0	26.5	11.2
	Diff. 30.8	27.4	14.4
75–79	Same 15.5	11.4	24.5
	Diff. 14.2	11.5	26.0
80–84	Same 15.1	12.0	24.7
	Diff. 15.2	12.5	23.2
85–89	Same 14.3	12.0	18.2
	Diff. 11.6	11.1	17.1
90–94	Same 10.5	11.6	12.7
	Diff. 9.5	9.6	9.1
95–100	Same 6.1	9.8	3.1
	Diff. 4.1	8.4	1.9

TABLE II

EFFECT OF CHANGE OF INSTRUCTOR ON GROUPS OF STUDENTS OF A DIFFERENT DEGREE OF INTELLIGENCE

Grades in Per cent	Tests	Examinations	Term grade
Below passing	Same 38.5	43.2	16.8
	Diff. 45.4	46.9	22.7
75–90	Same 44.9	35.4	67.4
	Diff. 41.0	35.1	67.3
Above 90	Same 16.6	21.4	15.8
	Diff. 13.6	18.0	11.0

The registrar's directions for reporting grades includes the following sentences: "Grades from 75 to 100 are passing grades. Grades from 60 to 74 are condition grades..... Grades below 60 are failing." The numerical grades which are given in this paper mean no more than the placing of a pupil on this scale set by the registrar.

Let us assume that a total of 11,723 students is a sufficient number on which to estimate percentages. If all of the pupils had the same instructor in recitation and laboratory, 1046 pupils who seriously began a quarter would furnish 1000 pupils to finish the quarter. This would be 12 more than would complete the quarter if they all had different instructors. Of the 1000, 59 more would have passing grades and 48 more have grades above 90% than if there were different instructors in recitation and laboratory. If all of those who drop or fail, re-enroll for the next quarter, the difference in work due to the added failures and drops would require almost all of the time of an additional instructor where a thousand or more pupils are enrolled. The extra failures and drops are not affected differently from all of the others in the classes. They are the least important ones for it is unlikely that they are good students. The deleterious effect on the average students and the good students, is less spectacular but more important.

Learning chemistry, like any other learning process, ultimately is altogether dependent on the pupil. But, as in all other learning processes, the environment affects the pupil's attitude toward the subject. Teaching is one of the influences brought to bear on a pupil to influence his attitude toward learning. Teaching is more than a parrot-like or phonograph-like repetition of paraphrases from a text. It is an active contribution from one person to another and the personalities of giver and of receiver are important factors in its effectiveness. If chemistry teachers and their pupils can become well enough acquainted so that to each other they are individuals with names and interests not just "Profs." and "Preps." there will be an improvement in the quality of chemistry teaching and the reputation which it bears.

THE ORIENTATION OF THE BONDS OF TERVALENT NITROGEN

J. A. NIEUWLAND, PROFESSOR OF ORGANIC CHEMISTRY, NOTRE DAME UNIVERSITY

The reference works and textbooks of organic chemistry do not seem to give a uniform or satisfactory way of illustrating the spacial relationship of the bonds of the tervalent nitrogen atom sufficiently explanatory to cover all the possible conditions, especially that of the isomerism of the aldoximes.

If the nitrogen atom lies in the same plane with the other two bonds in benzaldoxime, there should not be possible a condition admitting cis-transisomerism. Therefore, these compounds cannot have nitrogen bonds in the same plane. On the other hand if the nitrogen atom be shown at the apex of a tetrahedron (open or closed), with groups a, b, c, attached at the other corners, then there ought to be optical isomers as

in the configuration of the asymmetric carbon atom. Although many attempts have been made, no such isomers have been isolated. Teachers are, therefore, put in the somewhat anomalous position of explaining the orientation of amines and of oximes by two different schemes, or configurations.

If, however, we assume that ordinarily nitrogen has its valences distributed in three directions in one plane for the amines, the facts of experiment are in perfect agreement so far. Whenever nitrogen has two valences for one other element, as for example, for carbon in the aldoximes, ethylidene, etc., there is no reason why the application of Baeyer's Strain Theory would not play a part as it does in the case of double bonds between carbon and carbon as in ethylene, or in a ring system. One can suppose, then, that the two nitrogen valencies of the double bond, being drawn out of their angle of 120° by attachment to carbon or any other element, they will tend to draw in the remaining valence and its element or group to take the open tetrahedral configuration. It must be remembered that the nitrogen tetrahedron is open, unlike the carbon one with this element in the center. The remaining substituted element or radical will then be drawn to one side and out of plane with the other nitrogen valences. This will insure "molecular comfort." All the valences will tend to be so distributed that the third bond be directed in such a direction that its angle be equal as much as possible to the angle between double bonds themselves.

Hyponitrous and isohyponitrous acid, inorganic compounds with cis-trans arrangement, may be thus explained; the strain of a double bond in this case being between two nitrogen atoms. The preparation of the latter compound, however, points, according to some authors, to the formula of nitramide. It is, of course, obvious that the tervalent nitrogen atom in hydrocyanic acid cannot show cis-trans isomerism, because all of the nitrogen bonds are under equal strain, and are all used up in the union.

This status of the question postulates the opened tetrahedral formula for oximes and similar conditions, but appealing to Baeyer's Strain Theory explains why the ordinary distribution of nitrogen's valences in one plane are forced into the other configuration.

There is no reason why the strain theory should not be applied to other elements beside carbon, and it seems to me to be a very simple way out of a difficulty which I cannot find clearly explained anywhere.

A MODEL OF THE PERIODIC TABLE*

M. COURTINES, LABORATORY OF EXPERIMENTAL PHYSICS, COLLEGE OF FRANCE, PARIS

As is well known, the basis of the table is the remarkable but not altogether complete periodicity of the chemical properties (Mendeleeff) and of certain physical properties (Lothar Meyer) of the elements. The nature of our ideas on the subject has now completely changed. It is the number of electrons exterior to the atomic nucleus, equal to the charge of the nucleus, taking the charge of the electron as the unit, which determines the arrangement of the elements in a definite order. This number is furnished by physical measurements, visible, ultra violet and X-ray spectra, deflection of α-particles, etc. This leads to a classification of the elements by their successive layers of electrons, called K, L, M, N, O, P, Q; it is the formation of these successive layers which is at the foundation of the periodicity.

The accompanying table (Fig. 1) shows:

1. The arrangement of the electrons in successive layers.
2. The chemical relationships.
3. The physical relationships.

It is given in the form of a card model, which may be cut out and glued together, as is shown in Fig. 2.

Each square contains the symbol of an element in large black characters. Above and to the left is given the ordinal number, Z, which is the result of physical measurements. The card is folded in such a manner that elements 5 and 13 (B and Al) follow elements 4 and 12 (Gl and Mg). For this purpose the card is cut between Al, Si and Ga, Ge. Elements 26, 44, 76 (Fe, Ru, Os) are folded and glued, back to back, against the elements 25, 43, 75. Elements 28, 46, 78 (Ni, Pd, Pt) are glued in the same manner to the backs of the elements 29, 47, 79 (Cu, Ag, Au). The rare metals, folded like an accordion, are attached by gluing their ends to the backs of elements 56 and 73 (Ba and Ta) between which there is left a little window to receive the whole series of rare metals. Hydrogen (Z=1) is folded and glued to the back of helium (Z=2).

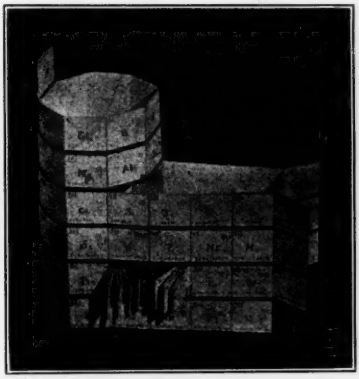


Fig. 2.

* This article was obtained through the courtesy of W. H. Noyes, University of Illinois, Urbana, Ill.

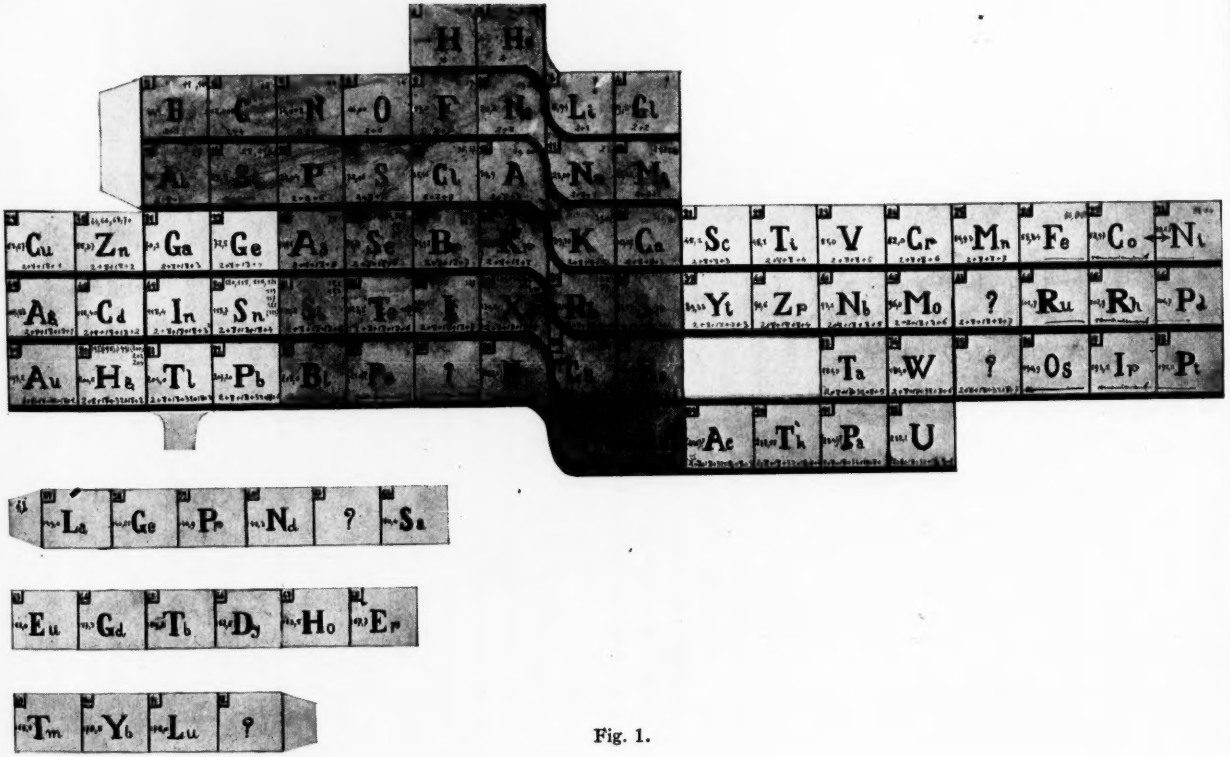
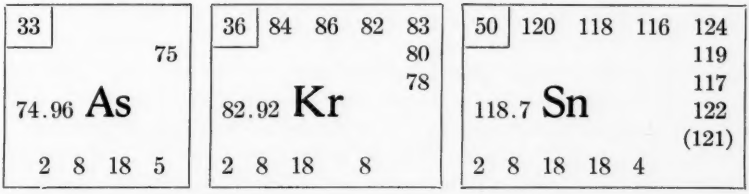

H
B
C
N
O
F
Li
Al
Si
P
S
Cl
Na
Mg
Cu
Zn
Ga
Ge
As
Se
Br
K
Ca
Sc
Ti
V
Cr
Mn
Fe
Co
Ni
Ag
Cd
In
Sn
Te
I
Rb
Sr
Y
Zr
Nb
Mo
?
Ru
Rh
Pd
Au
Hg
Tl
Pb
Bi
?
Cs
Ba
La
Ta
W
?
Os
Ir
Pt
Ce
Th
Pr
U
La
Ce
Pr
Nd
?
Sa
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu
?

Fig. 1.

When glued together in this manner, the model forms a tower, which is tinted gray, with a basement of white attached. This is shown in Fig. 2.

The numbers at the bottom of each square (to be given in red in the cardboard model) give the division of the extra-nuclear electrons in successive layers of the atoms. The numbers (to be also in red) at the left of the symbols give the atomic weights. There is also given in green at the right in each square the physical atomic weights as given by the mass spectra (Aston).

As these numbers cannot be brought out clearly in the scale used for the whole, the following illustrations are given to show what is intended:



The *tower*, whose middle face bears the noble gases, carries the elements which show close chemical relationships. It must have been these elements which guided the brilliant imagination of Mendeleeff.

The elements grouped in the annex are too far away from the normal arrangement of the noble gases for us to assign to them special chemical characters. In this zone the chemical periodicity, dear to Mendeleeff, disappears. But the physical periodicity remains. Column 24, 42, 72, 92 is that of the refractory metals. Column 29, 47, 79 is that of metals of high conductivity.

In general, when an electron is added to the exterior of the atom it has no effect on the interior layers except that the energy of the trajectory is increased. In the region 26, 27, 28, 44, 45, 46, 76, 77, 78 when an electron is added it falls to an interior layer; these layers are no longer inviolable; they are modified, not only in the number of electrons but also in their electronic value. They are called "continuing" (remaniement). The addition of an electron does not increase the outer layer but remains within the edifice.

"Refrain from illusions, insist on work and not words,
Patiently search divine and scientific truth."

MARIA MENDELEEF

TEACHING ORGANIC CHEMISTRY

EDWARD HART, LAFAYETTE COLLEGE, EASTON, PA.

It is true, is it not, that the teacher who is unable to put himself in the position of the pupil is unfit to teach ? If this be true, and I think it is, I shudder to think how many teachers of other things beside chemistry are unfit. It follows from a very superficial consideration of teaching, I think, that the view point of the beginner is all important.

Dr. James W. Moore once said to me: "When I studied chemistry the professor began somewhat as follows: 'We will begin by studying oxygen. This is a colorless, tasteless gas (and I did not know what a gas was). This gas is prepared by heating a mixture of potassium chlorate and manganese dioxide (and I had never heard of either) in a tubulated retort (and what is that?), collecting the gas in a bell jar (and what is that?) in a pneumatic trough (another unknown) over water. The retort is heated with a Bunsen burner as you see (I saw but did not understand) supported on a tripod (Ha! I had studied Greek—that meant three feet).' Do you," he asked, "teach chemistry like that?" and I found, to my dismay, that I did teach it very much like that. Fortunately this happened very early in my career as a teacher.

In the early days of organic chemistry teaching we proceeded by a method equally questionable. I was for a long time unable to see why students hated organic and seemed unable to assimilate it. After years of growing dissatisfaction with the result I concluded to undertake what I should have done long before, look at the matter through the eye of the student.

We began then with CH_4 spread out on the blackboard, like a flounder, with only two dimensions, length and breadth. Out of this we built up C_2H_6. Both of these concepts were an insoluble puzzle to the student. He lost interest at once and the game was lost.

I figured that I must give the boy something to do first, and arouse his curiosity. The destructive distillation of wood was something most boys had heard about. I told them more about it and we distilled wood in a simple cast-iron apparatus and collected all the products, gaseous and liquid and also examined the charcoal. We analyzed the gas in a simple form of Hempel apparatus and fractionally distilled the liquid after having first neutralized the acid with chalk or lime. The acetate of lime was then examined and, with some more acetate taken from a barrel, converted into acetic acid. Some acetate was heated and acetone prepared; from this we made chloroform and iodoform. The methyl alcohol was separated and methyl iodide prepared. This usually ended the half year's work, of two periods a week. By this time the boys were very much interested and extremely curious, for we had carefully avoided all explanations. All inquiries were answered by the statement that full explana-

tions would be given next term. Next term we trotted out the flounder with an entirely different result: the boys were eager to learn. The whole subject was pronounced hard but very interesting. Try this plan and see whether you like it. But map out the course carefully beforehand, see that the apparatus is simple and will work and let each student make his own apparatus, so far as is possible. And try out everything yourself first. If it fails in your hands be sure it will do so in his.

CHEMISTRY AS DEPICTED IN ART

ADELINE H. JACOBS, GERMANTOWN HIGH SCHOOL, PHILADELPHIA, PA.

The conventional row of portraits of distinguished chemists properly enough adorns the walls of many chemical laboratories and lecture rooms. Yet this display leaves much to be desired in producing a rich cultural background. A teacher of chemistry, with an appreciation of the fine arts, feels this lack keenly, especially after visiting the neighboring classrooms devoted to History, Latin, and English. In these rooms, copies of the art treasures from the Old World galleries find appropriate places and do much to create a decided cultural atmosphere.

With a determination to introduce pictorial beauty into the chemical department, the science teacher will find that the fine arts have much to contribute to her scheme. The following suggestions are sufficient to show the interesting variety of pictures worthy of a permanent place in wall decoration. Once the way is pointed out, the teacher to whom this feature of her work appeals will be able to make her own selection and discoveries.

A picture most fitting as a nucleus for the collection is "The Alchemist in His Workshop," in the Dresden Gallery, by David Teniers, the Younger. This is a different picture from the one on Page 11 of McPherson and Henderson's FIRST COURSE IN CHEMISTRY. A splendid Braun print can be purchased. The picture shows a hoary alchemist engrossed in his work, while his assistant, a cruder type of man, is seen in the background. The quaint interior is furnished with a clutter of old stoves, appliances and vessels used in a former era. The light in the picture is very artfully centered on the alchemist. High-school students are interested in the details of the picture, and in contrasting the difference in arrangement and equipment of their laboratory with the workshop of an alchemist of by-gone days.

"Dalton Collecting Fire-Marsh Gas" was painted by Ford Madox Brown for a mural decoration in the town-hall of Manchester. This picture is more than merely a portrait of Dalton. He is seen, out in the country, collecting the gas from a stagnant pool by stirring up the mud.

An assistant, in this case a farmer's boy, astride a log, catches the bubbles as they rise, in a wide-mouth bottle, having a saucer ready to close up the mouth under the water when full. A group of little girls, on the opposite bank, is looking on, wide-eyed at the strange performance. This charming picture, so full of human interest, is attractive to students studying the Atomic Theory. Prints can be obtained from J. T. Chapman, Ltd., Albert Square, Manchester, Eng.

Of an entirely different character from the realistic picture just described is the allegorical painting. Is it not worth while that students appreciate the fact that Sciences, and specifically chemistry, may form pleasing subjects for pictorial art? The Seasons, Virtues, etc., have been used in decoration for so very long. Now the Sciences are coming in for recognition in art. A valid objection to allegorical pictures is that they usually need a lengthy description to elucidate their meaning. One should select only those pictures whose significance is fairly evident. Above all, avoid too many allegorical pictures.

"Chemistry" by Puvis du Chavannes is a unit of the mural decorations of the Boston Public Library. A very fine hand-tinted photograph can be secured through the Employees Coöperative Society of the Library. A companion-piece to "Chemistry" is "Physics," of exceptional beauty. As these two are narrow panels, they look well framed together with a mat cut especially to fit them.

Another admirable allegorical picture is "The Sciences" by Kenyon Cox, found in the Congressional Library in Washington. Copely prints of it are sold by Curtis and Cameron, Publishers, 12 Harcourt St., Boston. These panels are three feet long.

In current magazines one may occasionally come across a picture worth framing. Usually the half-tones, run off by the thousands, are not fine enough for this, as they lack brilliancy in black and white tones or delicate gradations between these extremes. It is interesting to trace a desirable picture to its source and to secure a really good reproduction.

In February 1919, an article appeared in *The Little Journal*, Page 1, on the retiring of the president of the New York Chemical Club. He was presented with a handsomely engraved silver salver, elaborately decorated with a border of alchemistic symbols. The article was illustrated with a half-tone of the salver. Here was a half-tone of value. A printer's proof, better than the print in the magazine, was secured through the courtesy of the editor. The border was cut out, and in the center was inserted a paper bearing the words "Alchemistic Symbols" and the names of the symbols, to correspond with them in the border. The printing was done in fancy red and black lettering. A little red ink was used to set off the symbols from the decorated background.

When mounted and framed, the result was certainly unique and attractive. The students are frequently seen studying the details of this picture.

A quotation from the writings of any of the great chemists is appropriate for a wall decoration. The quotation should be treated like the conventional motto, *i. e.*, lettered and illuminated in colors and gold. The Art Department might coöperate with this project. The selection of the quotation takes some browsing among books. The name of the chemist and the dates of his birth and death should accompany the quotation; as

> 1742—SCHEELE—1786
>
> There is no delight like that which springs from a discovery; it is a joy that gladdens the heart.

"Fine prints and frames cost money," you teachers say. Yes; but the money may come as gifts from the Science Club or the graduating classes!

HIGH SCHOOL CHEMISTRY: THE STUDENT'S VIEWPOINT

A. J. CURRIER, PENNSYLVANIA STATE COLLEGE, STATE COLLEGE, PA.

Studies[1] which have recently been made reveal the fact that students who have studied chemistry for a year in high school, are, on the average, seriously deficient in their knowledge of useful chemical facts and in their ability to apply simple chemical principles. The following comments in this study by Powers are significant:

> Each of the tests of subject matter points to the conclusion that a considerable proportion of the content of high-school chemistry is of little or no value for many who study it. Certainly there are large numbers who effect no mastery of it. It appears that there are indeed many schools in which hardly any of the students obtain any mastery of the subject matter presented to them..... There is no escape from the conviction that there is urgent need for reorganization, and it is not surprising that this is so. The history of the teaching of chemistry in high school shows that the factors which have operated to determine the present course have not in any sense been purposely directed toward relating chemistry to the needs of those who study it. One of the main objectives of instruction in high-school chemistry is college preparation. A second objective frequently stated is to give a clear idea of fundamental principles. This second objective is one which in the first place is not achieved and which in the second place would be of doubtful value for general education if it were..... The need is now evident for an additional study which shall be devoted to the construction of a curriculum.

[1] S. R. Powers, *Teacher's College Record*, **25**, 203 (1924).

.....Curriculum studies in science must look to larger divisions than the individual units of physics and chemistry.....In brief, such a study will look to a determination of what people need to know about science and then to its organization into teachable units appropriate for the ability levels of high-school pupils.

It may be possible that the results of Powers' studies show that the student's chemical working tools are dull or lacking, when examined by the artisan in chemistry, and at the same time ignore what one might term chemical background or chemical appreciation—values which are less tangible than ability to write formulas or do calculations, but are equally if not more important to the average student. In any event, however, there is need for improvement and it is hoped that the outlines submitted in this paper may contribute to that end.

A careful examination of the table of contents of the average text book or the common outlines of courses of study reveals a long list of topics which to the beginner's mind are quite unrelated and foreign to his experience—a sort of chemist's inventory. "C'est[1] une énumération indéfinie de petits faits particuliers; Formules de combinaisions, densités, couleurs, action de tel ou tel corps, recettes de préparation, etc....."

The old expression, "the trees are so thick you cannot see the woods" applies to this situation. A hurried, more or less superficial study of a long list of unrelated topics, may be one of the primary causes of failure in many cases. It is a fundamental law of the mind that we remember what interests us and seems of real importance to us. A fact, a name, or a principle stamps its impression upon the mind when it is directly related to some other important idea. The principle of association of ideas, therefore, can be employed in reorganizing the subject matter of chemistry.

There are available, at least two studies of this problem of reorganization, having as their purpose, (1) the grouping of related topics, (2) the relating of subject matter more closely to everyday life. The first[2] of these papers places emphasis upon the project method.

This method is of value in the hands of experienced teachers, particularly in the study of the metals, near the end of the year after a thorough groundwork has been established. As a general mode of teaching high school chemistry, it has many disadvantages. A teacher of New England, of long experience in the secondary school, in discussing this problem recently with the writer, made this remark; "We are a long way yet from the general use of the project method. A great deal of good solid work in the regular text book is necessary if we are to teach the subject thoroughly."

[1] "Leçons sur Carbone" (preface), H. LeChatelier.

[2] Reorganization of Science in Secondary Schools, *Bulletin* **26**, 1920. U. S. Dept. of Interior, Bureau of Education.

The second paper[3] outlines the subject matter of high school chemistry under nine main topics, *e. g.*, "Chemical Energy in the Living World," "Chemical Mathematics," "Families of Elements," "Useful Metals," etc. In the discussion of this outline, Foster makes the following statement: "The organization of the first five large units of the foregoing outline is an outcome of experimentation continuing over a period of five years. This portion of the course, comprising approximately a semester's work has been given rather thorough trial and is considered a satisfactory organization."

The writer has endeavored to construct an outline somewhat after the pattern of the one by Foster, but more brief, and corresponding in subject matter, approximately to the "Syllabus for Secondary Schools," which is used in New York State, and to "A Standard Minimum High School Course in Chemistry."[4] An outline of this kind is hardly an original project, in fact, much of the material has been taken from the sources previously mentioned. A standard text book and laboratory manual is to be used with the outline, a mimeographed copy of which may be used to advantage by the individual student. The outline as a whole has not, as yet, been used in high school classes. The teaching experience of the writer, however, extending over a period of nearly ten years in both secondary school and college, justifies the hope and the conviction that the outline may be of service in our efforts to make general chemistry more definite and valuable to high school students.

I Introductory

(a) The nature of burning
(b) Heating metals in air
(c) Lavoisier's experiment
(d) Elements and compounds (briefly)

II Oxygen

(a) Essential to life and to burning; oxidation
(b) A constituent of water (electrolysis of water)
(c) NOTE: In the study of oxygen and other elements and compounds the important things are:
    (1) Where found (occurrence)
    (2) How prepared
    (3) Characteristics (properties)
        physical
        chemical

III Hydrogen

A constituent of water and all acids

[3] "The Reorganization of Chemistry in the Secondary School," L. F. Foster, *University High School Journal* (July, 1922) (Published by the University of California).

[4] THIS JOURNAL, 1, 87 (1924).

IV Measurement of Gases

(a) Effect of change in temperature and pressure on the volume of a gas (general),
(b) Instruments for measuring temperature and pressure
(c) Vapor tension of water (A measure of the tendency of water to vaporize)

V Water

(a) Composition of water by weight and by volume
(b) Properties
(c) Common impurities and methods of purification
(d) Factors which control the rate at which a substance dissolves
(e) Terms; solute, solvent, saturation, solubility, suspension

VI Composition of Substances

(a) Elements, compounds, mixtures
(b) Atomic hypothesis
(c) Weight relations; valence
naming of compounds
chemical equations
types of reactions
(d) Volume relations; principle of Gay Lussac
principle of Avogadro

VII Fuel Chemistry

(a) Carbon; natural and artificial forms
(b) Coal; kinds, relative advantages and disadvantages
(c) Carbon dioxide, carbonic acid, carbonates
(d) Carbon monoxide
(e) Electric furnace products; carborundum
calcium carbide
(f) Petroleum and distillation products
(g) Simple hydrocarbons; methane
ethylene
acetylene
(h) Gaseous fuels; natural gas
coal gas
producer gas
water gas

VIII Chemical Calculations

(a) Gram molecular volume
(b) Gram molecular weight
(c) Vapor density of gases
(d) Relation between vapor density and molecular weight
(e) Calculations
(1) Percentage of various elements in a compound
(2) Formula from chemical analysis
(3) Weight of substances formed from a given weight of material
(4) Volume of gaseous substances formed from a given weight of material
(5) Volume relations in reactions of gases

IX Salt, Alkalies (Bases), Acids, Salts

(a) Sodium chloride
(b) Sodium and sodium hydroxide; characteristics of a base
(c) Chlorine and hydrochloric acid; characteristics of an acid
(d) Neutralization; salts
    (1) Sodium carbonate
    (2) Sodium nitrate
    (3) Potassium nitrate
    (4) Sodium sulphate
(e) Theory of ionization (briefly)

X Air, Nitrogen and Nitrogen Compounds

(a) Air; composition by volume
    nature of air
(b) Nitrogen
(c) Ammonia
(d) Nitric acid; nitrates
(e) Nitric oxide; nitrogen dioxide
(f) Fixation of atmospheric nitrogen (in nature and in industry)
(g) The nitrogen family of elements (briefly)
    Uses of these elements and their important compounds

XI Sulfur and Sulfur Compounds

(a) Sulfur
(b) Hydrogen sulfide
(c) Carbon disulfide
(d) Sulfur dioxide and sulfur trioxide
(e) Sulfuric acid (contact process)
(f) Sulfates

XII The Metals (in Transportation)

1. Iron; importance of iron and steel in the transportation industry
    (a) Iron ores and their distribution
    (b) Cast iron; the blast furnace
    (c) Wrought iron
    (d) Steel (bessemer, open hearth, crucible, electric)
    (e) Special alloy steels
    (f) Iron compounds (two series)
2. Aluminium
    (a) Use in aeroplanes, automobiles and cooking ware
    (b) Thermite welding
    (c) Metallurgy of aluminium
    (d) Alums
3. Copper
    (a) Use in electric cables, motors, etc.
    (b) Alloys; brass and bronze
    (c) Refining of copper
    (d) Compounds of importance

XIII The Metals (in Construction Work)

1. Iron and steel (previously studied)

2. Calcium
   - (a) Natural compounds; limestone, marble, gypsum, etc.
   - (b) Manufactured compounds; lime, mortar, plaster, cement, concrete
   - (c) Hard waters
3. Lead
   - (a) Uses of the metal; plumbing and storage batteries
   - (b) Alloys; solder, babbitt metal, Wood's metal
   - (c) Compounds; paints
     - (1) Litharge and red lead
     - (2) White lead
4. Zinc
   - (a) Uses of the metal; galvanized iron, roofing
   - (b) Alloys; brass and bronze
   - (c) Compounds; paints
     - (1) Zinc oxide
     - (2) Lithopone
5. Tin
   - (a) Uses of the metal; roofing, tin cans
   - (b) Uses of compounds in textile and dye industry
6. Silicon (a nonmetal) (emphasize only general composition and practical uses of these materials)
   - (a) Sand and clay
   - (b) Glass; various kinds
   - (c) Brick and pottery
   - (d) Soapstone and asbestos

XIV The Metals (in Jewelry)

Silver, gold and platinum
- (a) Reason for high cost
- (b) Properties; relative chemical activity

XV Household Chemistry and Organic Compounds

- (a) Baking soda and washing soda
- (b) Baking powders
- (c) Soap (equations not required)
- (d) Action of hard water on soap; water softening
- (e) Common alcohols;
  - (1) Methyl alcohol
  - (2) Ethyl alcohol; fermentation
  - (3) Denatured alcohol
- (f) Common acids;
  - (1) Acetic acid; vinegar
  - (2) Oxalic acid
  - (3) Tartaric acid
- (g) Common carbohydrates;
  - (1) Starch
  - (2) Cellulose
  - (3) Glucose
  - (4) Cane sugar (inversion of sugar)

AN EXPERIMENT IN TEACHING

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We were just beginning the study of Oxygen and John had been called on to give an account of Priestley's experiment. He did this very well, concluding his recitation with the statement that "the red powder contained mercury and oxygen and was decomposed by heating." Further inquiry by the teacher called forth the statement that copper oxide contained copper and oxygen; zinc oxide contained zinc and oxygen; lead oxide, lead and oxygen; and other oxides contained oxygen and some one other element. When asked the question; "Could oxygen probably be obtained by heating other oxides than mercury oxide?" John ventured the opinion that it could be so obtained. Michael, following John's lead was quite sure that oxygen could be obtained by heating any oxide. In the face of this accumulating evidence Isaac was profoundly convinced that oxygen could be obtained by heating any oxide. Seeing how the previous recitations had been received without correction by the teacher, Angelo was willing to stake his reputation as a chemist that oxygen could be obtained by heating any oxide. Without making any comment as to the correctness or incorrectness of the statements just made by our four young philosophers, the teacher invited them down to the desk where they ranged themselves behind it, facing the class. Before each was placed a lighted Bunsen. John was given a tube containing lead oxide, Michael was furnished with one containing zinc oxide, Isaac received one containing magnesium oxide, and Angelo was given one containing copper oxide. Each was furnished with a wood splint and they were told to begin heating at the same moment and the class was to observe which contestant obtained oxygen first. The class was eager to observe the result. Quoting from Ben Hur, "The race was on. Over them bent the myriads."

In about five minutes, four disillusioned and wiser young scientific gentlemen silently laid four red-hot test-tubes down on the asbestos mats provided and solemnly marched back to their seats.

This experiment was made to bring out two points: (1) that simple oxides in general do not yield oxygen when heated in the laboratory, (2) that it is not the part of wisdom to follow the lead of the previous recitation unless you have thought it out and are sure that it should be followed.

I wonder if this was good pedagogy. What do you think?

THE PLACE OF ANALYTICAL CHEMISTRY IN AGRICULTURE[1]

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In considering the place which quantitative analysis should occupy in agricultural instruction several questions arise. Should quantitative analysis be required of *all* students in agriculture, required of certain groups, or should it be entirely elective? How much time should be devoted to the work? What subject matter should be included?

Perhaps a few words of explanation at this time may be helpful to those who may not be familiar with the chemistry which is usually required of the agricultural students. There is, of course, quite a little variation in the different institutions but the usual procedure is about as follows: Freshman year, general inorganic chemistry and qualitative analysis, given by the department of chemistry; Sophomore year, one term of organic chemistry and one term in pure quantitative analysis given by the department of chemistry. Following this a subject in general agricultural chemistry is usually given. Very frequently the quantitative analysis and organic chemistry are given in connection with the agricultural chemistry and sometimes both are omitted.

In order to learn what viewpoint was held by other workers in the field of agriculture, I sent out about one hundred questionnaires to persons teaching in agricultural colleges. About half of the questionnaires were sent to teachers of agricultural chemistry and half to persons teaching in other branches of agriculture. The questions asked were as follows: 1. Do you believe it desirable to require quantitative analysis of all four-year students in agriculture? 2. If so, how much should be required? A total of thirty-six teachers of agricultural chemistry representing the same number of institutions made replies as shown in Table 1. Of these twenty-three answered yes and eleven answered no, of which two preferred that it be offered as an elective, and two were indefinite in their replies. Thirty-eight persons engaged in other lines of agricultural work, such as dairy husbandry, animal husbandry, botany, agronomy, etc., replied as given in Table 2. Fifteen of these answered yes and fifteen no. Nine persons stated that quantitative analysis should be elective and nineteen that it should be required of certain groups of students. The number of semester credit hours suggested by those who believe that quantitative analysis should be required ranged from three to six with an average of four. Eight of those believing that quantitative analysis should be required prefer to have it given as agricultural analysis. An examination of the curricula

[1] Presented at the symposium on Analytical Chemistry held by the Chemical Education Section of the American Chemical Society at New Haven, April, 1923.

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TABLE 1

SUMMARY OF REPLIES RECEIVED FROM TEACHERS OF AGRICULTURAL CHEMISTRY

Institution number	General* chemistry credit hours Sem.	Term	Quantitative* analysis credit hours Sem.	Term	Qualitative* analysis credit hours Sem.	Term	Organic* chemistry credit hours Sem.	Term	Agricultural* chemistry credit hours Sem.	Term	Total hours Sem.	Term	Should quantitative be required of all students
1	7		None		2		3		2		14		No
2	10		As agr. anal.		In general		5		4		19		No
3	4		3		4		3		Elective		14		
4	10		Elective		Elective		10		2		22		No
5	8		None		In general		3		3		14		Yes
6	8		None		In general		3		3		14		No
7	5		3		5		3				16		Yes
8	10		Elective		In general		3		None		13		No
9	10		4		In general		4		None		18		Yes
10		9		3		3		5	None			20	Yes
11	8		None		In general				4		12		Yes
12	10		Elective		4		E. R. for some		R. of agron.		14		No
13	12		None		None		6		None		18		Yes
14		10	In agr. chem.		In general		In agr. chem.			10		20	
15	10		3		In general		None		5		18		Yes
16	6		None		3		3		None		12		Yes
17		5	None			5		5	Elective		15		Yes
18	8		None		None		4		4		16		No

* Amount given at present time.

TABLE 1 (CONCLUDED)

Institution number	General* chemistry credit hours Sem.	Term	Quantitative* analysis credit hours Sem.	Term	Qualitative* analysis credit hours Sem.	Term	Organic* chemistry credit hours Sem.	Term	Agricultural* chemistry credit hours Sem.	Term	Total* hours Sem	Term	Should quantitative be required of all students?
19	One year		None		None		One course		One term				
20	10				5		2		Not req.		17		Yes
21		9				6		8		10		33	Yes
22		12	In agr. chem.		In agr. chem.		In agr. chem.			13		25	Yes
23		8		5		4		5	In organic			22	Yes
24	6		Elective		3		Elective		None		9		No
25	6		6		In general		6				18		Yes
26	6		None		In general		In agr. chem.		4		12		Yes
27	9		In agr. chem.		In general		4		4		17		Yes
28	10		None		None		In agr. chem.		3		13		Yes
29		12	None		In general		Elective			5		17	Yes
30	8		None		None		3		2		13		No
31	3 term		In agr. chem.		1 term		1 term		1 term				Yes
32	10		R. and E.		In general		R. and E.		R. and E.				No
33	8		In general		In general		4		4		16		Yes
34	5		5		In quant.		3		3		16		Yes
35	4		None		None		None		4		8		No
36		9	In agr. chem.		3		3		6			21	Yes

* Amount given at present time.

TABLE 2

SUMMARY OF REPLIES RECEIVED FROM TEACHERS IN THE APPLIED SCIENCE SUBJECTS IN AGRICULTURAL COLLEGES

Institution number	1 Quantitative analysis required	2 Quantitative analysis elective	3 Quantitative analysis required of certain groups	4 Quantitative analysis required in agricultural chemistry
1	No	Yes		
2	No	Yes	Yes	
3		Yes	Yes	
4	No	Yes	Yes	
5	No	Yes	Yes	
6	No	Yes	Yes	Yes
7	No	Yes	Yes	
8				Yes
9	Yes			
10			Yes	Ye
11	No		Yes	
12	Yes			
13	Yes			
14			Yes	
15	Yes			Yes
16	Yes			
17		Yes	Yes	
18		Yes	Yes	
19			Yes	Yes
20	Yes			
21	Yes			
22	Yes			
23			Yes	
24	No			
25	Yes			Yes
26	No			Yes
27	No		Yes	
26	No		Yes	
29	No		Yes	
30	Yes			
31	No		Yes	
32	No		Yes	
33	Yes			
34	Yes			Yes
35	Yes			
36	No		Yes	
37	Yes			
38	Yes			

of thirty-six agricultural colleges shows that twenty-one institutions do not require this subject of all students while fifteen do. Of the total of seventy-four replies to the questionnaires thirty-eight were in favor of requiring the subject and twenty-six were not.

Usually our curricula in agriculture have been planned in such a manner

as to include during the first one or two years mainly the fundamental sciences upon which the practical or applied lines of agriculture are based. Chemistry has always occupied an important place among the fundamental sciences which include also botany, physics, etc. Within recent years, however, there has been an increasing tendency to introduce into the first two years some of the elementary subjects of the applied lines, which have been deemed advisable by many in order to create greater interest on the part of the student. Although this plan has many points of value in as much as it also gives the student an opportunity to become better acquainted with the various departments before choosing his major, if carried too far it leads to a crowding out of the curriculum of much of the fundamental sciences, a situation which may become very detrimental. The development of many highly specialized branches in our agricultural work also has resulted in a request that this subject and that subject be required until we find that it is necessary to weigh one against the other, in making a choice. The trend of modern education is toward those subjects which seem to offer training which will be of practical value to the students. It seems to me, therefore, that in view of these conditions quantitative analysis must furnish real reasons for the place which we assign to it in agriculture. Personally, I believe that it has a *place* in agricultural instruction and a very *important function* to perform.

With students in many diversified and highly specialized lines of study it seems to me that their needs for quantitative analysis will vary in quantity as well as quality. In presenting my own viewpoint upon this subject, I shall therefore divide them into the following groups: (1) All students in agriculture; (2) students specializing in certain applied lines where quantitative analysis will be of direct service as a working instrument as for example those majoring in soils, dairy manufacturing, plant physiology, animal nutrition, etc.; (3) those majoring in applied branches where quantitative analysis will not necessarily be of direct service as an instrument unless they go into teaching or investigational work; and (4) students specializing in agricultural chemistry. Because of the different methods of organization of departments and arrangement of curricula in the various institutions the discussion of principles rather than details will be of most value.

Considering first the four-year students as a group, they should all have sufficient training to enable them to interpret and use analytical data and to appreciate the painstaking efforts involved in the making of reliable analyses. Regardless of whether the students go into practical farming, extension work, teaching, etc., they will invariably have occasion to use and interpret analytical data. Many of these students will never be called upon to do analytical work. They are not interested in the subject from the standpoint of becoming trained analysts. A general knowledge of the principles and practices involved is of more value to them than the most re-

fined skill which can be obtained only with a great deal of practice. However, these students will have need for sufficient training to enable them to understand the meaning of analyses and to use them intelligently. Sufficient quantitative analysis to meet their needs can be given in the general course in agricultural chemistry either by using some quantitative experiments to illustrate the principles involved in this course or by devoting a term of the laboratory work to the analysis of agricultural products. Here again, perhaps, a few words of explanation may be helpful to those who may not be familiar with the type of work given in the subject of agricultural chemistry. This usually involves the study of the chemistry of agricultural materials, the chemistry of plants and the factors related to their growth and development such as soils, fertilizers, manure, lime, insecticides and fungicides, etc., and the chemistry of the animal and animal products, feedstuffs, etc. The use of quantitative experiments in illustrating the principles of the chemistry of soils, fertilizers, feedstuffs, etc., it seems to me, has several decided advantages over the requirement of a course in (pure) quantitative chemistry. In the first place many of the principles in agricultural chemistry can be taught more readily thereby and in the second place the interest of the student can be maintained easier if he is dealing with agricultural materials. This latter point is really important in as much as it has a significant bearing upon one of the most important laws of learning, namely, the law of effect. Those situations which lead to a response accompanied by satisfaction result in a greater strengthening of the bonds between situation and response than those which are associated with dissatisfaction. More interest can be aroused if the students are analyzing agricultural materials and consequently there is associated with the response a greater degree of satisfaction than if unrelated materials are used.

The subject matter covered should include the principles and practices involved in the taking of samples of agricultural materials for analysis, the use and care of the balance, the calibration of weights and glassware, the conception of normal solutions and other elementary principles of volumetric and gravimetric analysis. Most of these principles can be illustrated by the analysis of a commercial feedstuff.

In addition to the laboratory work the assignment of numerous problems involving the handling and use of analyses will aid a great deal in giving these students the type of quantitative chemistry which best meets their need.

Much could be said in favor of requiring quantitative analysis because of its disciplinary value regardless of its practical use. It is probably true that here such habits as shiftlessness, carelessness, etc., can be corrected most readily. These same desired effects can be obtained, however, by using agricultural materials.

Those students majoring in certain of the applied lines such as dairy manufacturing, soils, animal nutrition and plant physiology, where quantitative chemistry will be of direct service as a working tool present a different case. Such students will be called upon to make quantitative analyses after leaving college. They should be required to take sufficient quantitative analysis to enable them to do accurate work in their respective fields. They should either be required to take a course in quantitative analysis involving the principles of volumetric and gravimetric analysis previous to the special work in agricultural analysis or should be given a good theoretical training in connection with the latter. In case the latter plan is followed special pains should be taken to emphasize the theoretical side of the work. Here again the same argument holds for using agricultural materials and the principles can be taught just as well provided the theoretical side is not neglected.

Students majoring in the applied lines where quantitative analysis will not necessarily be of value as a working tool but who intend to take up teaching or investigational work should be advised to elect quantitative analysis. The needs of this type of student, it seems to me, are the same as those of the last mentioned group. The increasing use of chemistry by those research men working in the applied lines offers sufficient reasons for advising these students to elect quantitative chemistry. The field of horticulture at the present time furnishes a typical illustration. Many of the most important advances in practice secured by applying scientific knowledge have been made possible by a biochemical study of the problems involved. Horticulturists have sensed these opportunities and are showing more and more interest in chemistry.

In the last group, those students majoring in agricultural chemistry, we have a different situation from the other groups of students. They are graduated as chemists. These students should be required to take the same general quantitative analysis required of the students majoring in chemistry. This should include a very thorough training in the principles and practice of volumetric and gravimetric analysis and should consist of at least four credit hours of work throughout one full year. In addition they should be required to take at least six credit hours throughout one year in agricultural analysis. One of the criticisms frequently made regarding the training of agricultural chemists is that they have had insufficient training in analytical chemistry and I am inclined to believe that there is some justification in the criticism. A training merely in the skill of carrying out accurately the official methods of analysis is not sufficient. Combined with this there should be a very thorough training in the theory of the reactions involved and in the value and limitations of the methods. The assignment of problems involving analytical work with the provision that the student select the methods to be used will do much to help in this matter.

In conclusion, the speaker does not expect that all will agree with him in the ideas expressed. That is of little importance. If it will in any way stimulate discussion and an interchange of ideas regarding the problem involved his purpose will be accomplished. The unusual response to the questionnaires sent out and the thoughtful replies received indicate that there is general interest in the subject.

EDITOR'S NOTE:—Discussion following this paper resulted in a motion that the chair appoint a committee to study the teaching of chemistry in Agriculture and Home Economics. For report of this committee see THIS JOURNAL, **1**, 177 (1924). For discussion of this report see papers by C. H. Bailey and R. A. Dutcher in this issue.

THE TEACHING OF BIOLOGICAL CHEMISTRY*

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A few weeks ago Dr. Gordon, your Chairman, wrote me, asking if I would be willing to lead a discussion of the topic which is now before you, *i. e.*, "The Teaching of Biological Chemistry." Without giving the matter further thought, I foolishly consented, thinking that I would discuss the teaching of Biological Chemistry from the view point of the so-called "Agricultural Chemist." Had I known that Biological Chemistry was to be discussed in contradistinction to Agricultural Chemistry, I am sure that I would have demurred, for the reason that I have had little or no experience outside of the Agricultural field. When I discovered my error it was too late to notify your Chairman, consequently I decided that I would do my best to raise a few questions which might stimulate discussion. I must, however, discuss the teaching of Biological Chemistry from the standpoint of the biochemist who is employed in a School of Agriculture, and who is confronted with problems quite different from those which confront the biochemist in a medical college.

If you will pardon me, I am going to take my own institution, The Pennsylvania State College, as an example and show you some of our problems. Our organization is such that all biological sciences, zoölogy, botany, plant physiology, plant pathology, bacteriology, etc., are in the School of Agriculture. Furthermore all Biological Chemistry is taught in the Department of Agricultural and Biological Chemistry. We have therefore, five general types of students for which our courses are designed, *i. e.*, students majoring in (1) Agriculture, (2) Home Economics, (3) Pre-Medicine, (4) Agricultural and Biological Chemistry and (5) Sciences other than chem-

* Read in the Division of Chemical Education of the American Chemical Society at the Ithaca Meeting, September 11 (1924) during the discussion of the report by the Committee on "The Teaching of Agricultural Chemistry." See THIS JOURNAL, **1**, 177 (1924).

istry. I am enumerating these facts because I feel that opinions are often influenced by environmental conditions and in our case our opinions and methods are bound to be influenced by the types of students we teach and their respective needs.

Before continuing with my discussion it is only fair to state that I have been unable to differentiate between Agricultural and Biological Chemistry. The longer I work in this field the more I am coming to the belief that Agricultural Chemistry courses are undergoing a gradual transition. In fact it is safe to say that there are very few courses offered in Agricultural Chemistry today that can be classified as strictly agricultural. Aside from certain courses emphasizing the purely analytical phases, practically all agricultural chemistry is biological chemistry.

It was not so many years ago that a course in Agricultural Chemistry meant the routine estimation of crude protein in feed, solids in milk, or phosphorus in a fertilizer. These and similar determinations were ends in themselves. Today they are but tools and their old importance is gradually diminishing. I do not wish to leave the impression that I am belittling analytical training for I consider it one of the most valuable types of training the student can obtain. I wish to emphasize, however, that we are paying greater attention to the biological applications of chemistry. Our modern student in Agriculture, Home Economics and Medicine is coming to us with excellent foundations in botany, zoölogy, physiology, bacteriology and genetics. As a result the biochemist has found it his opportunity as well as his duty to stress the applications of his science.

Furthermore our progressive departments in animal husbandry, agronomy, horticulture and dairy husbandry are demanding specialized courses in chemistry with requests that we give their students all the theory that they can assimilate but that we keep their respective lines of specialization in mind with regard to illustrative material. As a result we (and others) have very successful courses in phytochemistry, soil chemistry, dairy chemistry, enzyme chemistry, and the chemistry of foods and nutrition. All of these, without exception, are taught from the viewpoint of the biochemist but with biological and agricultural applications. One of our very successful new courses "The Physical Chemistry of the Cell" is an example of the trend of the times. A "pure" physical chemist could not teach a course of this type, for his students would possess a knowledge of biology superior to that of their teacher. The same principle holds true in many other lines of biochemistry. In such courses, an instructor must not only be well trained in chemistry but he must be better versed than his students in the vocational phases or the biological phases of the subject.

The same general viewpoint is maintained in our courses for girls in home economics except that food values, food preparation, health and hygiene are the pegs upon which we hang our fundamental chemistry and biology.

It is no longer possible for a physiological chemist trained in animal biochemistry to teach a course in phytochemistry to juniors or seniors for the students may have had excellent training in botany, mycology, plant physiology and plant pathology. Biochemistry is becoming specialized.

Our viewpoints are changing very rapidly regarding the teaching of dairy chemistry. Now we recognize milk as a biological fluid. We are interested in its biological origin. We not only analyze it but we separate and study its proteins, we examine it with the ultramicroscope, the cryoscope and the viscosimeter. We are interested in iso-electric points and enzymes. This is not the dairy chemistry of a decade ago and I am wondering if we can call it "Agricultural Chemistry."

In physiological chemistry the same vocational or specialization interest is catered to. There is a decided tendency in all of these courses to emphasize more theoretical or pure chemistry than was the case ten or twenty years ago. The chemistry and physics of the colloidal state is influencing classroom and laboratory work.

In most of our biochemical courses we find that a judicious mixture of qualitative and quantitative laboratory work gives the best results. Students lose interest, as a rule, in purely qualitative work. Quantitative work gives the best training so far as precision, neatness and accuracy are concerned but well planned qualitative tests, isolations and syntheses offer excellent opportunities for introducing many new principles and theoretical applications in a short period of time.

Classroom material is presented as often as possible from the standpoint of research and, above the sophomore year, with the frequent use of original literature. In my experience every child is born with the inherent curiosity which prompts the demolition of the watch to see its wheels go round and although most of this attitude of mind is lost by the time the student reaches college, most of our students become very much interested in finding out how scientific investigations develop. This is one type of outside work that usually brings results.

In conclusion I will say that it will never be possible to standardize teaching nor is it advisable to try. One instructor will obtain excellent results by the use of methods and materials that would fail in the hands of another. We can all agree, within certain limits, concerning the subject matter to be covered in various courses, we can exchange ideas and experiences and benefit thereby, but that is as far as we will be able to go.

THE TEACHING OF BIOCHEMISTRY[1]

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Your Chairman has asked me to lead the discussion of the subject indicated by the title of this paper and, in this connection, to develop further some of the issues that were raised by the committee consisting of Professors Gortner, Read, and Kraybill, which committee reported on the teaching of agricultural chemistry at the Washington meeting last spring. In the report of this committee particular emphasis has been laid upon the desirability of modifying the teaching of general chemistry to students in agricultural courses in such a manner as to draw the illustrations largely from the field of agricultural sciences. I wish to further stress the observation that students who matriculate in agriculture do so because of their keen interest in that subdivision of applied science. They have a definite objective in pursuing their college course, and this can well be taken advantage of in developing the outlines of the various subject matter courses, including chemistry. This does not imply that the fundamentals of science need be neglected in the slightest. The committee evidently feels, however, that the instructors who handle the courses in general chemistry should have a certain familiarity with the problems of agriculture and a distinct sympathy with those problems and the objective of the students in the courses.

The title of my paper implies a little more general treatment of the subject, since biochemistry is of interest not alone to students of agriculture but to numerous other groups, including particularly medical students. There is a principle in biology that ontogeny repeats phylogeny, that is, that the history of the development of the individual is essentially that of the development of the race. May it not be that the same principle can be borrowed by the biochemical pedagogue in outlining a program of the chemical sciences for his students? Looking back over the development of biochemistry during the past fifty years we note that when it first emerged as a separate branch of the chemical sciences particular stress was laid upon organic chemistry. This was due to the fact that this was the heyday of the organic chemist, who was startling the world by the variety and complexity of the substances which he was able to synthesize and purify. Now biological substances are largely made up of organic material in a water sol or gel, and no well-trained biochemist can get very far without a fairly comprehensive knowledge of the characteristics of certain of these organic materials with which he is forced to deal. Whether he needs all the training in organic chemistry which is required of the student who proposes to restrict his activities to the field of organic chem-

[1] Read in the Division of Chemical Education of the American Chemical Society, at the Ithaca Meeting, Sept. 11 (1924), during the discussion of the Report by the Committee on "The Teaching of Agricultural Chemistry." See THIS JOURNAL, **1**, 177 (1924).

istry is doubtful, but certainly he must make a comprehensive survey of the carbon compounds. In such a course the instructor should draw his illustrations, so far as possible, from the materials with which the biochemist will later be concerned, and can substantially reduce the content of the extensive courses in organic chemistry to the extent of eliminating many of the detailed considerations of benzene derivatives. In discussing the benzene series much more advantage would accrue from the presentation of a few of the fundamental principles which appear to govern the reactions of typical carbocyclic compounds, rather than an extended consideration of the synthesis of various dyes and the like. One exception to this general statement should be noted. Those biochemists who propose to engage in pharmacological research need a more extensive knowledge of the carbocyclic compounds, and in many chemistry departments advanced courses in this subdivision of organic chemistry are already provided.

In the phylogeny of biochemistry the physical chemist made his appearance after the organic chemist, and, similarly, in developing a course for the present generation of biochemists a course in physical chemistry should be fitted, if possible, into the third year of the curriculum. Now there is a fine opportunity for argument as to which should precede, organic or physical chemistry. If we survey the average curriculum we find it is difficult to give the student the necessary training in mathematics to enable him to pursue a course in physical chemistry to advantage much before the beginning of the third year of university work, however, while the student can get along without this mathematics in the development of the work in organic chemistry. It is perhaps more difficult at the present time to find an instructional staff capable of teaching physical chemistry and at the same time familiar with the interests of the biologists. Recognizing this fact, we must turn our attention to the development of a corps of instructors adequate to this task. Certainly with the numerous physico-chemical phenomena which determine the progress of biochemical changes in living matter, no biochemist can consider himself adequately trained until he acquires a familiarity with the physico-chemical principles that are involved.

And finally we have the latest development in the field of physical chemistry known as chemistry of the colloidal state. The same remarks respecting the scarcity of trained physical chemists who are sympathetic with the problems of biology apply equally well to the present generation of colloid chemists. Certain schools are gradually training a group of instructors who will shortly be available in developing this subdivision of the science. A consideration of the colloidal state of matter should precede the usual consideration of the biochemistry of proteins, carbohydrates, and lipoids, since these materials occur in living tissue either

in that state, or in solution in the aqueous phase of a sol or gel. Their significance and behavior are consequently largely determined either by their colloidal nature, or by their effect upon the colloidal material with which they are in contact.

In one of the later stages of the phylogeny of biochemistry there was a period of intense interest in enzyme phenomena. Many of the supposed facts developed in this earlier period of interest are now regarded with some skepticism, however, and it appears quite probable that the subdivision of the chemistry of enzyme action is about due to be worked over, in the light of the increasing knowledge of physico-chemical principles and the behavior of material in the colloidal state. The rising generation of biochemists can undoubtedly bring their more extensive training to bear on the solution of some of these problems, and I feel that this constitutes one of the most fruitful fields of research now open to the young research worker. Likewise, the instructional staff must give careful attention to discoveries that are made in this field and be alert to add new facts to the content of his courses.

THE STANDARDIZATION OF WEIGHTS BY RICHARDS' METHOD

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Richards' method for the standardization of weights[1] has been found in this laboratory to excell both in simplicity and accuracy. There are, however, certain difficulties which arise in the teaching of this method. (1) The data form should include *all* of the experimental data and calculations, tabulated upon a single sheet. (2) There should be ample opportunity afforded for checking the standardization. (3) There should be somewhere available a mathematical proof of the accuracy of the method.

Weights placed on the left-hand pan	Readings of rider on beam		Weight in terms of the preliminary standard	Proportional parts of the final standard	Corrections in Mg
	With two or more weights taken together	With single weight			

If weighings are done by the method of equal swings as recommended by Wells[2] it becomes extremely easy to devise a data sheet having the proper requisites.

Experience has shown that with such a sheet, very few errors are made

[1] Richards, *J. Am. Chem. Soc.*, **22** 144 (1900).

[2] *J. Am. Chem. Soc.*, **42** 411 (1920).

in the first three columns. Numerical results in the derived columns can be checked over and corrected if necessary, avoiding in most cases, the entire restandardization of the set. Such a procedure of rechecking is impossible if columns two and three have been omitted and the correction determined by inspection as in the original article by Richards.* Furthermore, this scheme makes it possible to check any one weight separately without going through the entire set.

An important part of any calibration is the interchecking to make sure that the figures are consistent among themselves and that no cumulative errors have crept in. Hopkins, Zinn and Rogers[3] accomplish this by comparison of the derived values at certain intervals with Bureau of Standards weights. By altering slightly, this procedure may be used to furnish an indication of the excellence of the calibration of any set. If, for instance, a Bureau of Standards' 50 g. weight is given to the student as a final standard to which all of the weights are to be referred, then all of the weights are corrected in terms of the international kilogram. The check may take the form of an "unknown" exercise. A weight of approximately 49.99 g., the mass of which is accurately known in terms of the international kilogram can be given to the student as an "unknown." It will be noticed that such a weight will use all of the weights in a set, up to but not including the 50 g. Hence in determining the weight, all of the corrections will enter in. If the weight is reported correctly it is highly probable that the standardization has been accurate, furthermore the variation affords a measure of the quality of the work. This method of course necessitates for the instructor's use, a set of weights standardized by the Bureau of Standards.

In general, however, a set will not be standardized in terms of the international kilogram but in terms of some unit such that the corrections for the entire set shall be as small as possible. Checking may be carried out as follows without the use of Bureau of Standards' weights. Three weights are given to the student of approximately 51.01 g. (A), 49.99 g. (B), and 0.999 g. (C). The student is instructed to find the corrected weight of each of these and also to weigh (B plus 1 g. from this set) (D). Corrected weight D minus the corrected value for 1 g. should equal corrected weight B. This is merely a check for the use of the student. The ratio (A−B)/C should be reported by the student. A comparison of this value with the value obtained by the instructor using any accurately standardized set, furnishes a measure of the accuracy of the calibration. Zero to 0.01% variation from the correct ratio shows excellent work, while a variation of more than 0.05% shows a gross error.

* Revised reprints now being furnished to the students at Harvard Chemical Laboratory do contain a column for the rider readings.

[3] *J. Am. Chem. Soc.*, **42** 2528 (1920).

Briefly stated, the principle of Richards' method for the standardization of weights is as follows: The weights in a set may be compared among themselves in terms of any units whatsoever. The size of the unit may be altered so as to make the values conform closely to the face values of the weights, any variation in proportionality being taken care of by means of small corrections *which can under certain conditions be in terms of the original unit in which the arbitrarily chosen preliminary standard was expressed.*

A mathematical proof is given in order to emphasize that the correction as determined may be applied without appreciable error directly to the face value of the weight.

Let w_1 be the weight of the smallest weight to be calibrated in the set. This may be in any units whatsoever. Consider that the beam of the balance is divided into proportional parts, decimal parts for simplicity, and that the weight of the rider is also w_1 or that it differs from w_1 by a negligible amount.

Now with w_1 on the left-hand pan, counterpoise with any material whatsoever. Another set of weights makes a convenient counterpoise. Use the rider to secure the final balance being sure that it is approximately in the center of the graduated beam in order to allow for corrections. Now withdraw w_1 and replace it with w_2 of approximately the same mass. A change of e_2 of the rider on the beam will again secure a balance. Hence, since the beam is a proportional scale:

$$w_2 = w_1 + e_2$$

Repeating with another weight, w_3:

$$w_3 = w_1 + e_3$$

Place w_1 and w_2 together on the left-hand pan of the balance and counterpoise as before. Withdraw the two and replace them with w_4 of mass approximately twice that of w_1. A change of e_4 on the beam will again secure a balance:

$$w_4 = w_1 + w_2 + e_4 = 2w_1 + e_2 + e_4 = 2w_1 + E_4$$

and

$$E_4 = e_2 + e_4$$

This process can be repeated until we have corrections to be applied to all of the weights in the set. For any weight:

$$w_n = m_n w_1 + E_n$$

and

$$E_n = \Sigma e$$

as determined.

This means that w_n is m_n times as heavy as the weight w_1, plus a correction, E_n, all in terms of the preliminary unit of weight.

We might wish to choose w_k as our final standard.

$$wk = mkw_1 + Ek$$

It is important to notice at this point that the weights in terms of w_1 after applying the corrections as determined, are exactly proportional:

$$w_n - E_n = m_n w_1 \text{ and } w_k - E_k = mkw_1$$

The ratio between the corrected weights is m_n/m_k.

Unfortunately, w_k as measured in these preliminary units, does not correspond to the face value of the weight. Thus, if we wish to choose a weight marked 10 for our final standard, we might find that it had a value of 10.0184 in w_1 units. Hence, the w_1 unit which we chose as a preliminary standard was too small and if a unit 100,184/100,000 times as large had been chosen, then the face value of the 10 would have come out all right.

Let W_k = face value of k weight.

$$W_k = (m_k w_1 + E_k)\left(\frac{W_k}{m_k w_1 + E_k}\right)$$

or W_k in units of the face value of the k weight, equals the weight in w_1 units times a certain factor. Since this conversion factor will always have to be determined experimentally we may just as well call it $(1 + \delta)$.

$$\left(\frac{W_k}{m_k w_1 + E_k}\right) = (1 + \delta)$$

Or, the conversion factor from w_1 units to W_k units is equal to the ratio of the face value of the k weight to the observed value in w_1 units. Now in these new units, *i. e.*, in terms of the face value of the k weight:

$$(W_n)_t = \frac{M_n}{M_k}(m_k w_1 + E_k)(1 + \delta) \quad \text{Theoretically}$$

$$(W_n)_o = (m_n w_1 + E_n)(1 + \delta) \quad \text{Observed}$$

The correction to be applied is

$$(W_n)_t - (W_n)_o = \left(\frac{M_n}{M_k} E_k - E_n\right)\left(1 + \delta\right)$$

Since the correction in w_1 units is merely $\left(\frac{M_n}{M_k} E_k - E_n\right)$, the difference between the two corrections is in w_1 units:

$$\delta\left(\frac{M_n}{M_k} E_k - E_n\right)$$

If, as is usually the case, the E corrections are nearly proportional to the size of the weight[4] and if δ be small, then the product of the two becomes exceedingly small.

[4] Assuming exact proportionality $\frac{E_n}{E_k} = \frac{M_n}{M_k}$, and $\frac{M_n}{M_k} E_k - E_n = 0$.

Referring to the previous problem, a weight marked 1 was found to weigh 1.0016 in w_1 units. If its face value were correct, it should weigh one-tenth as much as the weight marked 10 or in w_1 units it should weigh 1.00184. Hence a correction of 0.00024 in w_1 units would have to be applied.[5]

$$(1+\delta) = \frac{100{,}000}{100{,}184} \qquad \delta = -\frac{184}{100{,}184} = -0.0018$$

The error in the correction[5] as determined above is

$$\delta\left(\frac{M_n}{M_k}E_k - E_n\right) = -0.0018\left(\frac{1}{10}\,0.0184 - 0.0016\right) = -0.000{,}00043$$

which is within the experimental error and entirely negligible.

Summary

1. A data sheet is given for use with the Richards' method of standardization of weights in which all of the data and computations are included on a single sheet.

2. A method is described for checking the accuracy of the calibration of a set of weights.

3. A mathematical proof is given for the Richards' method of standardizing weights. Conditions are determined for which the corrections in terms of the preliminary unit, may without appreciable error, be applied to the face values of the weights.

PROBLEM WORK IN ELEMENTARY GENERAL CHEMISTRY

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It seems to the writer that the solution of the problems involved in the ordinary course in general chemistry is made unnecessarily difficult by the use of too many "schemes" and formulas for doing the work. Such mechanical methods of solving problems do not train the student to think. The development of sustained thought and reasoning should be one of the main objects of a course in chemistry. Problem work is one of the most suitable vehicles for use in developing this ability. The student usually thinks of chemical arithmetic as some different kind of mathematics from anything he has ever heard of before. As a matter of fact the arithmetic of the calculations is the same kind he learned in the grammar school.

[5] The correction as used in this proof represents the quantity which would have to be added to the weight in order to secure exact proportionality between the weights. In practice the correction is given the opposite sign so that the sum of the weights plus the sum of the corrections will give the corrected weight of the object.

The largest allowable variation in δ varies inversely as the largest correction in the set and is 0.02 for a correction of 1 mg. This error may be made still smaller by a proper choice of the preliminary standard.

When the student is trained to rely on the use of formulas and mechanical devices, he obtains the impression that unless he remembers the particular scheme applicable to the type of problem under discussion, he cannot possibly get the right answer.

The chief function of problems in general chemistry is the illustration and application of principles. When problems are solved in such a manner that the student sees the application of the law or principle, he soon has this law fixed firmly in mind. When he merely substitutes figures in a formula, he obtains the right answer, provided he has made the substitutions in the proper manner, but gains little by doing so. For the purposes of general chemistry the actual numerical answer is usually of little importance. The important part of the calculation is the thought used by the student in correctly applying the principle. When he works by formula or mechanical scheme he does no real thinking. This has been done for him by the author of the text he uses and he has merely to memorize the result and do a little multiplication and division. The teaching of multiplication and division is not one of the important functions of a course in chemistry.

The authors of some of the texts in general use have adopted the common sense method of solving some types of problems. A few authors use it for most of the problems. In the majority of the texts in common use, however, according to the observation of the writer, the student is told to solve problems involving changes in gas volumes by substituting numerical values in a formula; problems involving weights of materials entering into chemical reaction by a well-developed scheme; and problems involving the volumes of gases in chemical reactions by first finding the weight and then the volume through the use of the weight of one liter. The writers experience leads to the conclusion that such problems can be much more easily solved and a higher per cent of correct answers obtained if in all such cases the student is taught to work them out on a "common sense" basis. Furthermore, a much more important result is obtained in that the student who must constantly work out problems of this kind becomes familiar with the principle involved because he must think as he works.

The problem work in elementary general chemistry, through a first year college course usually includes most of the following types: derivation of the formula of a compound from the percentage composition and the reverse; corrections in gas volumes for changes in temperature and pressure; weights of substances involved in chemical reactions; volumes of gases required for, or liberated in, chemical reactions; problems based on Faraday's Law; problems involving molarity and normality of solutions; calculation of molecular weight from vapor density measurements and from freezing point depression or boiling point elevation; and calculation of atomic weights from experimental data.

Little need be said about the first two types mentioned above, but the writer would like to discuss some of those which follow in order to indicate the method of attack which he has found useful in teaching the application of the principles involved instead of the mechanical calculation of a numerical answer.

Problems involving changes in volumes of gases due to changes in temperature and pressure are introduced into the course in general chemistry for the purpose of emphasizing the "gas laws." The numerical answers which the students obtain and the calculations which they make have little importance unless this purpose is kept in view and the problems are solved in a manner such that the "gas laws" are constantly in the minds of the students. When the calculation is based on the formula,

$$\frac{PV}{T} = \frac{P'V'}{T'}$$

this purpose is not accomplished. The better students will learn the derivation of this formula once and promptly forget it. Usually the student will simply memorize the formula. Solving the problem merely involves substituting numbers in this formula. The student rarely thinks why the numbers stand in the order given, and frequently makes his substitutions wrong and obtains the wrong answer. There is, however, a much more fundamental objection to this method of attack. The average student sees no connection between the gas laws which are being illustrated and the problems which are used for this purpose. He therefore, derives no benefit from the reiteration which results from solving numerous problems of this type.

The purpose for which these problems are used can be accomplished if the method of solving is one which requires the student to think in terms of the gas laws, and not simply to remember a formula and guard against its incorrect use. For accomplishing this end, the simplest method of solving problems involving gas volume corrections consists of multiplying the observed volume by two correction fractions, one for the pressure change and the other for the change in temperature. In order to express these fractions properly the student must use a little common sense reasoning. The fact that an increase in pressure results in a decrease in the volume of gases is one of common observation. The pressure correction fraction will, therefore, contain the smaller of the two pressures in the numerator if the new pressure is higher than the old, because this will give a smaller volume. Similarly, if the new pressure is lower than that observed the larger of the two pressure values will be in the numerator because common sense tells us that gases expand when the pressure is reduced. Again, every one knows that hot air rises, which means that it is less dense or has expanded. Consequently, in order to apply the temperature correction

it is merely necessary to change the temperature values to the absolute scale, and to make a correction fraction of these numbers with the larger in the numerator if the new temperature is higher than that observed. When the student solves his problems in this way, he uses facts which are common to his own experience as the starting point in his reasoning, and he thinks in terms of the gas laws in every such problem he solves. It is easier for the student to solve his problems in this manner than by the use of the above-mentioned formula, he does not forget the formula for there is none involved, and the constant repetition gained by solving many such problems impresses the quantitative relations, known as Boyle's and Charles' Laws firmly on his mind.

For the solution of problems involving reacting weights, the student should first write the equation unless the molecular ratio is obvious without the equation. He should be made to realize that the formulas used in these equations represent definite weights of the substances involved and that the mole is the significant chemical unit of weight. The calculations can then be made very simply in terms of the fractions of moles involved. For example, one desires to calculate the weight of oxygen which can be obtained from 12.26 g. of potassium chlorate. When the equation is written it is seen that 2 moles of potassium chlorate yield 3 moles of oxygen, or that 1 mole of potassium chlorate yields $1^1/_2$ moles of oxygen. Therefore, 12.26 g., which is $^1/_{10}$ of a mole of potassium chlorate, will yield $^1/_{10}$ of $1^1/_2$ moles of oxygen, 4.8 g. of oxygen.

If the reasoning involved above appears too difficult for the beginner, a method which is simpler and less mechanical than the "schemes" usually given follows. In this method, the calculation is made just as would be done in any other similar problem in arithmetic. 2×122.6 g. of potassium chlorate yield 3×32 g. of oxygen. 245.2 g. of potassium chlorate yield 96 mg. of oxygen. 1 g. of potassium chlorate yields 96/245.2 g. of oxygen. 12.26 g. of potassium chlorate yield $12.26 \times 96/245.2$ or 4.8 g. of oxygen. If one goes into a fruit store to buy oranges and finds that they are 60 cents a dozen, he does not require a pencil and paper to figure by proportions how much he must pay for 4. He thinks almost instantly 60 cents for 12, 5 cents each, 20 cents for 4. This is the kind of arithmetic learned in the fourth or fifth grade in grammar school and is as complicated as the arithmetical work need be for the calculation of reacting quantities of material. The definite "schemes," so much insisted upon by some, serve to make a simple matter difficult. What is needed is insistence on the student learning that the equation is a quantitative expression. Chemistry is involved in determining the amounts of materials entering into chemical reactions only to the extent of writing a correct equation to represent the reaction. (The knowledge of chemistry gives the information as to the price of oxygen in terms of potassium chlorate, etc.) After that it is the

simplest kind of arithmetic. Problems of the type just mentioned should be studied at the beginning of the course and frequently reiterated as the course progresses. The emphasis should be placed not on some "scheme" for use in solving the problem, but on the quantitative meaning of the equation. If that is learned no scheme is necessary and the method of attack does not matter very much.

The calculation of the volumes of gases involved in reactions can be made directly from the equation, for the formula of a substance which is a gas signifies 22.4 liters of that gas under standard conditions of temperature and pressure. It does no harm to first calculate the weight and then divide by the weight of one liter in order to find the volume. But what is the use?

Suppose that we desire to know what volume of dry oxygen, measured under standard conditions of temperature and pressure, can be obtained from 12.26 g. of potassium chlorate. As in the above case, we obtain from the equation the relation that 1 mole of potassium chlorate yields $1^1/_2$ moles of oxygen. A mole of oxygen, under the conditions given, occupies 22.4 liters. Therefore, 1 mole of potassium chlorate will yield 33.6 liters of oxygen and $^1/_{10}$ mole of potassium chlorate will yield 3.36 liters of oxygen. For conditions of temperature and pressure other than standard, corrections will now be made according to the gas laws.

The solution of problems based on Faraday's Law serves to emphasize the significance of the term "gram equivalent weight" and its relation to the mole of compounds and the atomic weights of elements. The simplest method of attack is based on the fact that 96,500 coulombs of electricity liberate a gram equivalent weight of material at each of the poles. The same fraction of a gram equivalent weight will be liberated as the fraction of a faraday of electrical energy expended.

If the student really understands the significance of the terms "mole" and "gram equivalent weight" and the calculations involved in the foregoing paragraphs, he will have little difficulty with calculations which involve the use of solutions, whose concentration is expressed in terms molar or normal. He will know that a 1-molar solution is one which contains one mole per liter and that he can substitute this volume of solution for the mole of material in the calculations. When the concentration is expressed in terms normal he needs to know also the relation between the gram equivalent weight and the mole of the substance in the solution in order to know what volume does contain one mole. The same kind of "common sense" reasoning used above will enable him to calculate the volumes of solutions of given normality or molarity required for certain specified reactions.

The examples discussed in the preceding paragraphs will serve to show clearly what the writer has in mind in saying that the student receives more benefit from solving his problems by common sense reasoning than by the use of mechanical schemes. For the majority of our students who do not

take more advanced courses in chemistry, the mental training which they receive is the matter of greatest importance. No mental training of importance is given by the use of mechanical schemes and we should make every effort to develop sound reasoning at every opportunity.

The writer wishes, therefore, to make the plea that teachers of general chemistry, both in secondary schools and in college courses, teach problem work in such a manner that the student may see the connection between the arithmetical work and the principles which this work is designed to illustrate to the end that the student may learn to think in terms of these principles.

A PLEA FOR INTEREST*

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I have just finished reading with much interest Dr. Ferguson's article[1] on "The Course in High School Chemistry." I agree most heartily with him on one point, namely, that it is impracticable to have high school pupils get experimental data in the laboratory sufficient to derive the laws and theories of chemistry for themselves. Although this is the way in which the laws were discovered, one year is not sufficient time for the student to do thoroughly what has taken the human race hundreds of years to accomplish. Furthermore, I doubt very much if young people seventeen and eighteen years of age are mature enough to follow through a mass of data in order to formulate some of our principles. It is unwise to teach abstract material to these young students if it is beyond their undeveloped powers of appreciation. It merely confuses and causes needless distaste for the subject.

For the reason just stated I differ with Dr. Ferguson when he deplores the present tendency to emphasize "the chemistry of industry, of commerce, of the soil and of the household" in contrast to the older course of study which stressed "laws, theories and fundamental principles." "The tendency.....seems to be to make all work appear like play and as a result we are developing a play-crazy generation." Personally, I cannot understand why subject matter which is interesting or useful is necessarily lacking in educative value. It is those subjects which grip one with interest which affect one throughout life. After all, education is the establishment of worthwhile interests. Librarians have said that the books of fiction which are read least are those which are studied in high school courses of English. This means that the pupil has no desire to read and

* This paper resulted from a note at the end of Dr. Ferguson's article found in THIS JOURNAL, **1** 188 (1924). Dr. Ferguson has been asked to reply to this paper in the March issue of THIS JOURNAL.

[1] THIS JOURNAL, **1** 183 (1924).

reread the masterpieces which should thrill him. To me, this indicates failure in education. Unless our teaching of chemistry leaves the student with the desire to explore farther than we are able to take him in an elementary course it too is a failure. He will not do this if it is not intensely interesting to him.

Dr. Ferguson maintains further that "the ability to correlate facts, to make accurate observations, to draw logical conclusions, to stick to a thing and see it to the end are qualities and habits which a course in real chemistry given by a real teacher will develop." These qualities are highly desirable but the statement needs proof. In general do pupils have these qualities to a greater degree *after* they have had one year in high school chemistry than they did before? If they do, I have not noticed it.

After all, it is not a question of principles versus facts but a question of giving a student the scientific point of view through a few facts which are useful and which stimulate interest.

SOME MISCONCEPTIONS OF CHEMICAL EDUCATION

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This article is in no sense polemic against the views of any one who has written in the JOURNAL OF CHEMICAL EDUCATION; nevertheless, in developing its subject, it will be necessary to oppose views that have been published by some writers in THIS JOURNAL. The purpose is far more modest. It is to show that certain misconceptions have in the past retarded and are still actively retarding the development of chemical education. As I sense the situation, chemistry is not likely to take the place it deserves in education, not likely to be studied by anywhere near all the pupils who should do so, not likely to give the pupils all the benefits it should, while our work is organized upon the basis of certain very prevalent misconceptions. It is, therefore, desirable at this time to call the attention of the teachers of chemistry to the fact that they have not attained as scientific a point of view and procedure with regard to education as they have with regard to the subject matter of chemistry which they teach.

First and foremost among the misconceptions prevalent in the minds of chemistry teachers, in high schools and colleges alike, is a psychological doctrine which is of the same degree of validity as the phlogiston hypothesis which chemistry rejected over a century ago. I refer to the belief that the chief actual or desirable outcome of chemical instruction is a "general training," a "discipline," a set of "general abilities," such as those labelled "to observe accurately," "to draw correct or reasonable conclusions," and the like. This doctrine is neither more nor less than a belated survival from a pre-scientific psychology. It is based upon the

supposition that the human mind consists of a series of "faculties," each of which may be trained by appropriate exercises in any field of knowledge, and whose power, once gained, may be applied at will in any field. That such "faculties" or general powers do not exist has been repeatedly shown by the psychologists; and, if we are to be scientific in our approach to chemical education, we must recognize this fact.

But there is a still further set of facts available, perhaps more relevant than the disproof of the theory of mental faculties. Since 1900 the educational-psychologists have been conducting many experiments on what they call "transfer of training" or "spread of training." It has been shown, repeatedly and in the most varied types of learning, that the amount of spread or transfer of training from one mental activity into others, even if closely similar, is small, erratic in its occurrence, and extremely variable from one individual to another. This is not the place to cite in detail the evidence. For a comprehensive survey of the data see Starch's "Educational Psychology," Chapters 13 and 14.

It is relevant, however, to point out that even in such apparently similar kinds of mental work as memory for words or symbols seen, and memory for words or symbols heard, the improvement in either due to training in the other, is for most pupils so small as to make it unwise to count upon it in any educational work. This is even more strikingly true of such things as "power of observation," "openmindedness," "self-confidence," and the like.

We shall make far greater progress in chemical education if we recognize, for example, that there are numerous specific kinds of observation, each one of which has to be learned separately, and each of which has its own associated group of habits, skills, mental attitudes, and the like. As a practical teacher of both chemistry and biology, I have noticed that the mental set induced by observation in biology is, on the whole, more apt to interfere with observation in chemistry than to aid it. There is even a similar antagonistic working or at least non-coöperation between visual and auditory observation, as any physics teacher will know from the difficulties met with when teaching sound.

There is in each department of knowledge and each department of human affairs a necessary minimum of knowledge of fact which is required for openmindedness to be possible; and the very items that cause openmindedness in one field are sometimes, unless added to, the same as make for closed-mindedness and prejudices in others. During the World War, for example, we had the spectacle of a well-known chemist writing in *Science* to the effect that certain social phenomena should be simply opposed or denounced, without the least trace of an openmindedness that would have seen these to be legitimate objects of study in the same way as polymers, formerly dismissed by chemists, have of recent years been found a field for chemical work.

The second misconception which is hindering the progress of chemical instruction is an insistence upon what might best be called "covering a logical outline of the science as a whole." This is best shown in the existing codes for high-school instruction published by various states and cities and by examining boards. The result of this insistence is that such parts of chemistry as do not happen to fit into this scheme, but that would be of value to the pupils in enabling them to live better, to meet the situations that they have or are likely to have to face, are left out, in favor of logical abstractions, isolated facts for memory, or industrial processes of interest only to the chemical technologists. Let me be specific on this, using the chemistry of iron and its compounds as an illustration. Logically, it would appear desirable to teach about a number of the inorganic salts of iron, about the various metallurgical processes, and about the chemistry of the metal in its different industrial forms. Yet it is a safe assertion to say that not one item in twenty of these is likely to be of any educational value to most of the pupils. A rudimentary treatment of such iron-containing compounds as hemoglobin, showing the rôle they play in life-processes, though doubtless unsatisfactory to the chemist, offers greater possibilities of benefit to the pupils.

Our third misconception, arising either paired with the last, or derived from it, is that we are teaching the subject rather than the pupil. Our organization of courses in terms of the logic of the subject, instead of in terms of the possibilities of educational benefit to the pupil is here involved. Let us realize that, however fine our plan for a course in chemistry may be, that it is only that part of it that the pupil actually gets—not what is taught him, but what he learns—that has justified its place in school. What we need to do is to eliminate from the course, rigidly and despite any predilections that we may have, those items that do not get learned by the pupils. Men[1] have already shown what some of these items are.

Cognate with the last two misconceptions is another one affecting all our courses. We have been working on the basis that the first-year course in chemistry, whether taught in high school or taught in college, is only an introductory course, to be followed by other specialized courses. As a result, the first course, and the second for those who follow high school chemistry with freshman college work in the subject, is really neither more nor less than the first stage in the instruction of a technical chemist. The content included is such as is of value mainly to one who expects to be a chemical engineer, an analytical chemist, or a research chemist. Here and there attempts have been made to specialize college freshman chemistry,* and a few schools have introduced a half-year of "Chemistry of

[1] S. R. Powers, "A Diagnostic Study of the Subject-Matter of High-School Chemistry." Teachers College, Columbia University, Contribution to Education 149.

* Notably the Washington Square College of New York University.

Practical Life" as an introduction to the more systematic course.* But these are exceptional cases, not yet affecting chemical instruction as a whole.

The remedy which I propose for this situation is that the high-school chemistry course should be revised with the basal idea that those who take it are not going to study more chemistry, that they are not going to be chemists, and that their specific needs should be met. It is certain that the existing courses do not meet their needs.

The last misconception which I desire to treat is that of thinking and acting upon the basis that chemistry is essentially a mass of information. The College Entrance Examination Board, with its examinations in chemistry consisting, on the average of the ten years 1913–1922, of 87 per cent memory questions,** which has done much to make this situation. Our other examining bodies, such as the Regents in New York State, have done no better. Even our test-makers have fallen into this same error for the most part. If we examine all the available standardized tests for achievement in chemistry, we shall find that the Bell test is almost entirely a memory test, the Cleveland Coöperative tests ditto, Gerry's test ditto, Powers' tests ditto (qualified by a section involving skills and habits, but not thinking.) My own tests represent the first attempt to get away from this misconception.

To sum up: we shall not get far ahead with advancing chemical education until we relieve ourselves of the misconceptions clogging the field. Some of the more significant of these are: the doctrine of formal discipline; the desire to cover the subject "logically;" the attempt to teach the subject rather than the pupil; the assumption that the beginning course is preparatory in nature; and measuring results in terms of information acquired.

Some Things Not Learned in the Classroom. WILLIAM HOSKINS. *News Ed., Ind. Eng. Chem.*, **3**, No. 2, 6 (1925).—William Hoskins, the "dean" of Chicago industrial chemists, gave a very interesting talk to the Chemistry Journal Club of Northwestern University recently on the subject "Some Things Not Learned in the Classroom." Mr. Hoskins' classroom experience ended half a century ago when he completed a concentrated two-year course in high school. He stressed the importance of a university training for the chemist of today, however, even though it can make no pretense of giving him all the knowledge for which a consulting chemist is sometimes called upon.

Mr. Hoskins advised every young graduate chemist, first, to get some experience in an industrial laboratory and, second, to start doing something on the side in which he is especially interested, whether it is some sort of research or a manufacturing process. The big thing, he said, was to start to do something and to keep working. The first problem would soon lead to something bigger or better, and a never-ending sequence would be started. Mr. Hoskins' talk was well illustrated with interesting stories and reminiscences, and was a real inspiration to young chemists and students.

* Notably certain high schools in New York, N. Y.

** Data computed by me and to be published later.

Chemical Digest

SOME SUGGESTIONS OF THE PAST YEAR FOR SOLVING THE PROBLEMS OF FIRST-YEAR CHEMISTRY

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In the following brief resumé no attempt has been made to give a complete abstract of any paper but rather to bring together some of the ideas of the past year concerning first year chemistry.

The organization of The Division of Chemical Education of the American Chemical Society and its decision to publish THIS JOURNAL has given an impetus to the study of conditions affecting the training of our young people in chemistry in both high school and college. In addition to the report of this committee on the correlation of high school and college chemistry a number of other researches have been made to determine existing conditions and to better them.

Louis W. Mattern,[1] suggests that the qualities needed in the study of chemistry are those which produce success in modern life. Accurate observation, correlation of observation and the laws deduced therefrom, independent judgment based on experimental evidence, thoroughness and clear expression are named among these qualities. For the best development the author suggests that at the very beginning the student should be brought into full harmony with the fact that chemistry "is guided by fundamental principles, or laws, which find a great variety of material expressions and is not a mere memorization of unrelated facts and bugbear equations."

From the industrial field comes[2] the suggestion that first-year chemistry in the school should be devoted not so much to making the student absorb some minimum of knowledge as to a study of his trend and abilities. During this first year he states that such qualities as memory, system of thought and action, imagination, patience, exactness and neatness should be studied in order to advise wisely as to which phase of the profession should be attempted if any at all.

A. P. Sy[3] finds that the proportion of high school students electing chemistry as their science requirement, in many places at least, is far below that for either physics or biology and suggests as the chief reason why chemistry is not more popular that too much of the more or less obsolete and unnecessarily difficult matter is taught. This he believes

[1] *Sch. Sci. Math.*, **23**, 665 (1923).

[2] M. G. Korsunsky, *Ind. Eng. Chem.*, **15**, 186 (1924).

[3] THIS JOURNAL, **1**, 25, (1924).

is largely the fault of the textbooks, most of which "shoot over the head of the average student." Too many start with the more difficult and, to the beginner, unattractive and non-essential matter. An appeal is made for more intelligible terms instead of those which convey either the wrong meaning or no meaning at all to the first-year student. In his opinion there is need for greater clearness in the language of the chemist as well as a breaking away from the conventional form of textbook.

An interesting survey[4] of some twenty-seven institutions throws considerable light on what is being taught the beginner. An examination of the most generally used texts showed them to contain approximately 70% descriptive and 30% theoretical matter while the emphasis of the teachers was found to be about the reverse. A study of examination questions coming from these institutions led the authors to suggest that questions should be objective, should be worded so that answers are an act of reason rather than memory, should be short and of greater number and should coincide with the emphasis in the classroom.

There appears to be a quite general belief that laboratory work should precede and set the pace for class-room development; also that every experiment should lead to the development of fundamental principles and their application. One writer[5] goes so far as to suggest that the student's entire time be scheduled for the laboratory. While he would not entirely do away with lectures to the whole group, he states that a regularly scheduled course of so many hours per week does not seem desirable for beginners. Quizzes and written tests may easily be handled in the laboratory if the sections are kept small. It would have the advantage of close contact between teacher and student, would make possible the granting of credit for quantity of satisfactory work done and would enable students to be advanced according to individual ability to progress. Since advancement in the business or professional world will depend on individual ability, "why not," he asks, "train the student in college on the same basis on which he is going to be judged when he enters the world of affairs?"

An earlier and greater use of the periodic system is suggested as a means not only of holding the interest of the student but also of making a more connected and unified course. One teacher[6] at least would use it from the very beginning, even in the high school. He argues that it is simpler than the multiplication table and "nature's own golden thread running through first-year chemistry." He would lead the students, by a general study of the first eighteen or twenty elements, to discover the periodicity for themselves and through a series of steps, including variation of proper-

[4] Jacob Cornog and J. C. Colbert, THIS JOURNAL, **1**, 5 (1924).
[5] Alexander Silverman, *Ind. Eng. Chem.*, **16**, 860 (1924).
[6] P. M. Glasoe, *Sch. Sci. Math.*, **24**, 700 (1924).

ties, positive and negative character of the elements, basic and acidic qualities, and types of compounds and their formulae to the subject of valence which by this time becomes necessary for the explanation of some of the things the students have already discovered. He includes a form of periodic table to which he would make daily reference since the "table alone gives a true perspective and the correct relationships between the elements." While such use of the periodic law would mark a considerable departure from the usual textbook method, the reviewer believes there is much sound argument for its more general use and has discussed this at some length elsewhere.[7]

More specific in their nature but not less valuable are the lecture demonstrations used to clarify theories or to illustrate principles and laws. Among those appearing in our journals during the past year may be mentioned "A New Lecture Table Outfit for Demonstrating Conductivity to Elementary Classes,"[8] a diagram of which is given in connection with a description of its use. An interesting and simple experiment to show that conductivity is due to ions is described[9] for the reaction between H_2SO_4 and $Ba(OH)_2$. A 5% solution of $Ba(OH)_2$ is placed in a beaker with platinum electrodes connected in series with a lamp and alternating current source. While the solution is stirred dil. H_2SO_4 is added from a burette. As the base is neutralized the light grows dimmer and finally goes out when neutralization is complete. That light produces chemical reactivity is demonstrated[10] by the reaction $C_6H_5CH_3 + Br_2 \longrightarrow C_6H_5CH_2Br + HBr$. Pure toluene is placed in a glass reaction vessel connected with a dropping funnel containing bromine and a U-tube partially filled with water. When bromine is dropped into the toluene little or no reaction takes place in the dark or even in the light of the ordinary lamp but if placed in the focus of a projection arc light a vigorous reaction is noticed as the color of the bromine disappears and HBr is driven over into the water. On removing the arc light the reaction ceases. A diagram of the apparatus is included with the description.

While this is by no means an exhaustive review, enough has been given to show the trend of thought as it affects the first-year chemistry student and to bring to our minds the fact that the problem is by no means solved, but that the profession, though apparently engaged in pure or applied research, has not lost sight of its foundation stone, the elementary training of the first year.

[7] Geo. W. Sears, THIS JOURNAL, **1**, 173 (1924).
[8] Herbert F. Davison, THIS JOURNAL, **1**, 74 (1924).
[9] Otto O. Watts, *J. Am. Chem. Soc.*, **46**, 1210 (1924).
[10] Konek and Loczka, *Ber.*, **57B**, 679 (1924).

ABSTRACTS

The Carbon Atom in Crystalline Structure. SIR WILLIAM BRAGG. *Nature*, **114**, 862–5(1924).—It must be our aim to explain the properties of materials in terms of atoms. Some progress has been made in the case of the gas and liquid states, but very little is known of the relation between the properties of solid material and of the atoms of which it is built. When groups of atoms or molecules associate to form a solid, they arrange themselves in a regular pattern. X-rays show a universal tendency to crystallization. Carbon constitutes only about a thousandth part of the earth's crust, yet it more than any other element impresses itself upon living bodies. The *diamond* has a simple and symmetrical structure. Each carbon atom is surrounded by four others, which are grouped about it in perfect symmetry. The hardness and rigidity of the diamond show that the forces are primarily exerted along four lines drawn from the center of a tetrahedron to its corners. *Graphite* consists of layers of carbon atoms, the atoms being arranged as a hexagonal network in each layer. The forces between atoms in the same layers are exceedingly strong, while the forces between layer and layer are very small. The structure of calcite, naphthalene, and anthracene are considered, also long-chain molecules of the fatty acids, hydrocarbons, etc. WILLIAM FOSTER

The Natural and Artificial Disintegration of the Elements. SIR ERNEST RUTHERFORD. *Sci. Monthly*, **19**, 561–78 (1924).—The author assumes a knowledge of the disintegration of the radioactive elements and certain of the lighter elements, and confines his attention to the structure of the nucleus. He assumes the positive charge on the nucleus as given by the atomic number and indicates that the helium nucleus plays an important part in the building up of all nuclei. The important problem is to obtain definite evidence of the nature and arrangement of the components of the nucleus. In a region close to the nucleus the ordinary laws of force are valid. He describes the effect of the bombardment of nuclei with swift alpha particles and finds that the law of inverse squares breaks down for very light atoms. It seems that when nuclei approach within certain critical distances of each other, forces come into play which vary more rapidly than the inverse square. He points out that the long series of radioactive transformations give modes of transformations, but give very little that enables one to interpret this data. The remainder of the paper deals with problems involved in studying the structure of nuclei and methods of attack. It is a very good summary of the work done up to the present time on the solution of the "greatest problem of physics." J. E. WILDISH

Stickiness of Clay Useful in Warfare Against Insects. *Science Service.*—Speaking before the Am. Assoc. of Econ. Entomologists, L. I. English, of Iowa State College, at Ames, told of the use of a very fine colloidal clay which he has found to be an efficient aid in making emulsions of various kinds of oils for use in spraying apparatus. One of the oils used was auto engine lubricating oil. B.

New Use for Ethylene. *Science Service.* Ethylene, safer and more satisfactory than laughing gas, is coming into general use for the operations of minor surgery such as those in dentistry.

Some Educational Values in Laboratory Work. W. G. POWERS. *Education* **44**, 546–55 (1924).—It is important for the beginner to have laboratory work. Whether he does the laboratory work himself or sees some one else do it may not be material, but he must be acquainted with the processes by which it is done. Support for this statement is the fact that chemistry has developed as a result of laboratory study. The values discussed are from (1) training in scientific thinking, (2) training in individual, independent methods of work, (3) holding interests. Other writers including Goddard, Segerblom, Tyler, Morgon, Mathews, Elliott, Newell, and Gordon are quoted. The article is throughout an argument for the values of laboratory work. S. R. POWERS

The Possibilities and Limitations of Training. L. M. TERMAN. *J. Educ. Research*, **10**, 335–43 (Dec. 1924).—As a result of an extensive study of intelligence testing, T. raises such questions as (1) Is good teaching more favorable to school achievement than is poor teaching? (2) With certain groups, is much teaching more effective than none? (3) Is group instruction profitable? He is inclined to the belief that greater value rests in the native ability of the student than in the proficiency of the teacher. The Nat. Soc. for the Study of Educ. has appointed a committee with T. as chairman to investigate "the possibilities and limitations of training." B.

Requirements for Appointment and Promotion of Members of the Faculty of the University of Michigan. *Sch. and Soc.* **21**, 42 (Jan. 1925).—A junior instructor must (1) have a substantial knowledge of the subject as evidenced by his collegiate record, (2) show a definite promise of teaching ability and (3) show a distinct interest in scholar-

ship and research. An instructor must (1) have taken graduate work or have had professional experience, presumably the doctorate or its equivalent, (2) show evident teaching ability and (3) have demonstrated ability to do research work under guidance. An assistant professor must have demonstrated his ability as a teacher, scholar or independent investigator or must have had valuable professional experience. An associate professor must have a well-established record for original scholarship and an equally well-established reputation as a teacher. He must have contributed to an authoritative journal or have prepared a treatise or textbook of acknowledged value. For the full professorship the record for original scholarship should be sufficient to give at least national reputation within the profession. In case the candidate falls short in any requirement as set forth in this plan, higher standing will be required in the other qualifications. This is the first scheme of such exacting nature to be adopted in the U. S. B.

Heat of Absorption of Oxygen by Charcoal. E. A. BLENCH AND W. E. GARNER. *J. Chem. Soc.*, **125**, 1288–95(1924).—A vegetable charcoal, freed from ash, moisture and gases, was treated with O_2 at 20–450° C. The heat of absorption per mol. of O_2 was from 60 to 222 cal. The authors believe that at low temperatures (below −185) O_2 is adsorbed as molecular oxygen, while at higher temperatures single atoms combine with C to form complexes represented by C_xO_y on the surface of the charcoal. Some of the groups seem to be stable while some are unstable—the unstable ones undergoing rearrangement to produce CO and CO_2. Supporting the work of Rhead and Wheeler, the authors found that adsorbed Oxygen is given up even when the temperature is raised from 200 to 900°. FRIEND E. CLARK

Chemistry and Peace. J. B. S. HALDANE. *Atlantic*, Jan. 1925, 1–18.—An interesting and authoritative presentation of the history and principles of gas warfare and a sound defense of gas as a weapon. Every citizen, particularly the chemist, should be acquainted with his arguments. H. consistently adheres to the thesis that war cannot be prevented by merely objecting to it, "however lofty our motives or disinterested our conduct," but that it may be "prevented by scientific study of its causes, such as has prevented most epidemic diseases." B.

Discovery of Polyhalite in Texas.—This potash-bearing mineral has been discovered in the oil wells of western Texas and eastern New Mexico. When pure it contains 15.6% Potassium Oxide. In color it ranges from dark brick-red to light red or salmon, or it may be colorless. It is composed of the sulfates of magnesium, potassium and calcium. It is soluble and, as all sulfates are beneficial to most soils, the rock as mined would be a water-soluble fertilizer. This fertilizer would be good for the western cotton and beet sugar regions and for the fruit-growing country, to which it could be supplied in competition with the low-priced German and French potash. Polyhalite occurs in connection with salt beds known to underlie an area of about 100,000 square miles in Texas, New Mexico, Oklahoma and Kansas. These beds are of great thickness and on an estimated average of 200 feet contain 30,000 billion tons of rock salt, the largest known deposit. The salt was deposited from the sea millions of years ago, long before the Rocky Mountains were in existence. At times the concentration of this sea water by evaporation became so great that not only common salt (sodium chloride) was deposited, but also potassium salts. The area embracing the discoveries of potash hitherto made, is about 275 by 125 miles. The most promising region lies between the 101st and 104th meridians and between parallels of 31° and 33°, in the Staked Plains of western Texas and southeastern New Mexico. These occurrences of polyhalite are in the Permian formation, as it is named by geologists, the formation in which the German beds also occur. Potash occurs in many rocks but becomes available for plant food slowly by weathering of the rocks. For intensive agriculture this process needs to be supplemented by artificial fertilization, and in many agricultural regions there are no such rocks. No important attempt has yet been made to mine potash in the United States, but it is being successfully extracted from Searles Lake brines. As depletion of natural soil fertility progresses and industrial demand for potash increases the importance to the nation of the polyhalite deposits in Texas and New Mexico will be apprehended. ENGINEERING FOUNDATION

Correcting Examination Papers. RETHA E. BREEZE. *School Rev.*, **33**, 57–61 (1925).—The results of a study conducted in Will Mayfield College. If an examination is expected to serve merely as a "measuring stick" for the instructor or as a stimulus to the student, its purpose is accomplished as soon as the paper is in the hands of the instructor. Present study indicates that an examination may be of added value to the student, provided (1) his corrected paper is returned to him and (2) the correct answers are discussed by the instructor, special attention being given to errors. B.

Chemical Laboratory Study. J. S. LONG. *School and Society*, **20**, 735–9(Dec.

1924).—Practice on standard instruments simply for the sake of experience with such instruments is work on the trade school level. Students should consider apparatus as replaceable tools. Too much emphasis is laid on memory work with the result that scientific thought and curiosity are not properly stimulated. A few experiments properly chosen enable the student to devise means of testing his own hypotheses and to deduce independent generalizations. L. is in favor of including Qual. Anal. in the first year, with such emphasis on mass action, solubility product, etc., that it is lifted from the realm of "cook-bookery." The same emphasis should follow in Quant. Anal. and Org. Chem. L. advocates holding quizzes on the "whys, whats and wherefores" of expts. before allowing the student to attempt actual experimental work. Notebook reports should be reduced to a minimum. As the most important factor in the scheme of instruction, the teacher must be competent and experienced. Much harm comes from the practice of intrusting beginning students to the care of young inexperienced instructors. M. F. WADLEIGH

Thoroughness in Science Teaching. ALWYN PICKLES. *Educ. Outlook*, **76**, 354 (Sept. 1924).—Instruction cannot be speeded up without risk of failure, for students of science are prone to mental indigestion. There is a vast difference between the amount of ground covered in the teachers' imagination and that covered in actuality. There is a marked tendency when hurried to pass over lightly the uninteresting parts, whereas all things that are important should be made interesting. Thoroughness is a prime essential and bears no direct relation to the total number of experiments performed. Unless progress is so slow as to kill interest, "too little is preferable to too much." A science course should be planned as a whole and plenty of time allowed for mastery of the essentials. B.

The Electron and Light Quanta—What are they? R. A. MILLIKAN. (The Nobel address by the winner of the 1923 prize in Physics.) *Scribner's*, Jan., 1925.—"Science walks forward on two feet, theory and experiment." A description of the niceties of his famous "oil-drop experiment," followed by the basic proofs that the electron is the unit of matter. "The electron itself is neither an uncertainty nor an hypothesis. It is a new experimental fact that this generation in which we live has for the first time seen and which any one who wills may henceforth see." M. also states that "the reality of Einstein's light quanta may be considered as experimentally established." The address concludes with an acknowledgement of the extraordinary success of the Einstein equation and conception as well and a review of the present frontier problems of the physicist. M. F. WADLEIGH

Interviewing the Stars. WILLIAM J. SHOWALTER. *Nat. Geog. Mag.*, **47**, 97 (1925).—The article could be appropriately renamed, "The Chemistry of the Stars." Teachers of chemistry are constantly tempted into a self-sufficiency within their own subject. Educators, patrons and pupils demand that we pull down the walls to allow our subject the free range of the universe, touching and appropriating all to which it can show claim. S. describes the discovery of He in the sun, its later identification in uranite, natural gas and the decomposition products of radium. Various theories of light are described and the prediction made that we will eventually have "radio movies." The need of more efficient utilization of the sun's energy is discussed. The unbelievable density of the star Sirius suggests that the constitution of matter is very imperfectly known. S. substitutes for the chemists' laboratory test tubes and beakers, the "cosmic crucibles of the skies." He also describes Anderson's attempts at the Mt. Wilson Observatory to explode atoms of Te, W, Pb, Al and Ca. He accepts light as coming from the electrons shifting orbits within the atom, and explains the spectrum in these terms, emphasizing its use in "interviewing the stars." B. CLIFFORD HENDRICKS

Achievement in High School Chemistry—An Examination of Subject Matter. S. R. POWERS. *Sch. Sci. Math.*, **25**, 53 (1925).—The basis of the study consists of eight test forms used in 60 schools by pupils ranging in numbers from 500–1200 for each test. 350 test items show the ability of pupils to write chemical formulas, names, and equations, classify elements, mixtures, and compounds; solve problems and place metals in activity list. Pupils ranking low in one test were low in most of them and lower in the smaller schools. The writer considers the work in some schools entirely futile. There is need of reorganization for the aims are not realized. Study should be given to the construction of a curriculum which will look to what people need to know about science, and then organize it into teachable units for the ability of high school pupils.
H. R. SMITH

Sulfur. ALBERT G. WOLF. *The Explosives Eng.*, **3**, 7 (1925).—(A description of the Frasch Process as used to obtain S from the costal plain deposits of Tex. and La.—written by a mining engineer of the Texas Gulf Sulphur Co., which operates in this

district.) Over 99% of the brimstone produced in the U. S. (approx. 2 million tons in 1923) and over 75% of the world's output is mined in this region. Upthrusts of numerous salt domes below cause local surface elevations 10–15 ft. above the surrounding prairies. About 60 such domes have been located; only four now produce S. Domes are from 0.5 to 2 miles in diameter and are of unknown depth. The tops are nearly flat while the sides slope sharply. A capping of sulfate minerals and calcium carbonate overlies each core, the latter containing the S. When S is present, which is not always the case, "the carbonate stratum is thick, quite porous and contains native S in crystals and masses." It is usually found at a depth of 1000 ft. or more. Wells are drilled by the rotary method; casings are set down only to the top of the S-bearing rock, while the holes are continued on through to the bottom of the deposit. Pumping equipment which is set into the well consists of a 6″ pipe which reaches to the bottom; inside this a 3″ pipe which reaches almost to the bottom and inside this a 1″ pipe which extends to within about 20 ft. of the bottom. The lower end of the 3″ pipe rests on a flange within the 6″ pipe, closing the annular space between them. Above and below this flange there are numerous holes in the 6″ wall. Water at 325–335° F. is forced down between the 3″ and 6″ pipes and out through the upper holes into the S-bearing rock. The relatively heavy melted S runs down, enters the lower holes and rises considerably over 100 ft. inside the 3″ pipe. Air under a pressure of at least 500 lbs. is forced down the 1″ pipe, producing an air lift between it and the 3″ pipe. The light froth of air, water and sulfur flows out at the ground level as "an amber foaming liquid." This is poured directly into wooden forms, which sometimes have an area of several acres. Only a few inches of melted S are present at any one time. Layer upon layer is thus built up until the resulting solid block is from 35 to 55 ft. high and may contain a million tons of S. This is better than 99.9% pure. For shipment the S is removed by blasting, one ton of permissible explosive breaking an average of 20,000 tons of S. B.

Wood Alcohol Less Harmful than Grain.—Alcohol relations appear to be reversed in the barley world. Wood alcohol is less harmful than grain alcohol. This is the inference from some recent experiments performed here, in which barley seedlings growing in water cultures had varying quantities of the two alcohols added to their culture solutions. One part of grain alcohol to 1000 parts of solution proved fatal but plants lived when the concentration of wood alcohol was five times as great. In the case of those plants growing in non-killing strengths of alcohol it was noticed that the grain alcohol favored the production of ear or reproductive shoots, whereas the wood alcohol favored the growth of ordinary leaves. When the dose of alcohol was withheld until the plants were well under way it required more alcohol to poison. Old barleys stand up better than the young in the presence of alcohol. SCIENCE SERVICE

Cooking Not Destructive to Vitamin Value of Foods. Cooking destroys vitamins, yet cooked foods may have adequate vitamin values. This paradox was stated before the annual convention of the National Canners' Association here this evening by Prof. Walter H. Eddy of Columbia University, a widely-known specialist on the subject of vitamins. Prof. Eddy cited as an example the studies some years ago which indicated that ordinary cooking temperatures in an open kettle destroyed as much as ninety-five per cent of the anti-scorbutic vitamin, or vitamin "C." It was assumed, following these experiments, that cooked vegetables were entirely useless as a means of preventing scurvy and similar deficiency diseases. However, a test was later determined upon, and increased quantities of the cooked foods were fed to experimental guinea pigs. It was discovered that even the small fraction of vitamin remaining in the cooked vegetables was sufficient to have the desired effect in the prevention of disease. This depends on the fact that vitamins are very powerful substances, and a little goes a long way. Further experiments with foods cooked in sealed containers under pressure, with air excluded, showed that the vitamin content was impaired much less than it was in open-kettle cooking. The delegates to the convention received this statement with interested comment, for canned vegetables are cooked under pressure. Prof. Eddy stated that the cooking conducted in his laboratory was done in pressure cookers similar to those now used extensively in home canning. Though he encouraged his audience in the matter of the effects of cooking methods in the canneries, Prof. Eddy warned them against excessive blanching of their products, saying that carried too far such processes destroy valuable vegetable sugars and salts, and have a deleterious effect on the vitamins. SCIENCE SERVICE

Copper from Still Causes Liver Hardening. Copper, dissolved from the "worm" of the still during the making of liquor, is a cause of the disease popularly called "hardening of the liver," rather than the liquor itself, Dr. Frank Burr Mallory, of the Boston City Hospital, has just announced to the medical profession. Copper in foods pre-

pared in copper vessels or colored green with copper salts can produce the same malady. Chronic copper poisoning is a more common disease than has been thought, he says, for in 3.4 per cent of a large group of post mortem examinations he has found evidences of its harmful action. Copper starts the poisoning of the system by causing the red coloring matter of the blood to decompose, forming a yellow pigment. This condition of the blood Dr. Mallory calls "Hemachromatosis." The yellow pigment accumulates first in the liver, but when the liver becomes overloaded it gathers also in the pancreas, kidneys, lymph nodes, heart, thyroid and adrenal glands, and the skin of the hands and feet. In the liver the cells where the pigment accumulates sicken and die. New cells grow, but the tissue thus formed is more like tumorous growth than healthy liver cells. Hardening of the liver follows. Accumulation of the poisonous pigment in the pancreas causes a breakdown of the tissue, followed by diabetes. When the adrenal cortex is attacked, abnormal darkening of the skin follows. So far as Dr. Mallory has observed, the kidneys are able to repair successfully whatever mischief is done there. The liver, however, is always the first organ to suffer. Copper poisoning is always slow in showing its effects. "Clinical cases show that ordinarily it takes fifteen to twenty-five or more years to produce the symptom complex," says Dr. Mallory. He places considerable stress on the importance of copper as an impurity in alcoholic drinks, and has investigated many samples of bootleg liquor seized by the Boston police. In nine out of eighty-four seizures of cheap "hooch" he found appreciable amounts of copper, and he has shown the metal to be present in home brew and fortified wines as well. In several of the cases he examined, the victims were habitually alcoholic. One of them, an ex-bartender who had turned bootlegger, had drunk a pint of whiskey and four or five glasses of beer every day for many years. Copper poisoning as the result of inhaling or swallowing copper dust is also suggested. Three or four of the cases were men who had worked in machine shops where copper filings and dust were produced in quantity, and at least one of them was not a drinking man. Finally, Dr. Mallory suggests that poisoning may result from the eating of foods prepared or kept in copper vessels, or canned foods, like peas and pickles, colored green with copper salts. "Now that the danger of poisoning has been pointed out," concluded Dr. Mallory, "steps should be taken to prevent copper from getting into liquors and foods, and to protect workers in occupations involving copper from inhaling or ingesting copper dust." SCIENCE SERVICE

Bakelite Transparent to Infra-Red Light. Transparency to infra-red light is the remarkable property discovered in bakelite, the American synthetic resin, now widely used for radio panels and phonograph records. The discovery was reported by M. Georges Kimpflin to the French Academy of Sciences. The transparency is not so high as that of window-glass with common white light, but still offers interesting possibilities of mechanical application. Infra-red light is not visible to the human eye. Recently secret-signal systems have been developed for military use, based on infra-red radiation. It now appears possible to filter the light of the secret signal through bakelite so that the tell-tale visible rays are excluded. Furthermore, filtered infra-red rays are expected to have medical application in the practice of dermatology. Bakelite may be doped with iron and certain other useful ingredients without seriously reducing its infra-red transparency. The new experiments recall the recent development in America of a black glass, impervious to common light, but transparent to ultra-violet light, the opposite extreme of the spectrum. SCIENCE SERVICE

Useful Pigment Now Made Electrically. Electrical means for manufacturing carbon black, a widely used pigment, have been devised by the Bureau of Mines, U. S. Department of the Interior. Carbon black consists of exceedingly finely divided particles of carbon, and is at present produced by burning natural gas with an insufficient air supply, and permitting the flame to impinge on a cool metal surface. This method has been found strongly objectionable in many communities, and stringent ordinances have been passed to regulate its manufacture. Inasmuch as carbon black is in great demand in the manufacture of printer's ink, shoe and stove blackings, phonograph records, black leather, typewriter ribbons, carbon paper, and many other articles, a method for manufacture that does away with the objectionable though inevitable dirtiness of the present process has been much desired. The Bureau of Mines process involves the use of high voltage discharges from electric arcs acting upon cheap light-oil distillates. SCIENCE SERVICE

Modern Trend in the Science of Ventilation. PERRY WEST. *Am. Sch. Board J.*, **54,** 6 (1925).—A detailed discussion of practical standards of ventilation. Air supply and air distribution are discussed under the term effective air supply. Calculations show that an adult could exist indefinitely on the oxygen in air supplied at the rate of five cubic feet per hour. Practically only 25% of the oxygen can be extracted, and

therefore 20 cubic feet of air will sustain life. This produces an atmosphere containing 300 parts of carbon dioxide per 10,000 parts of air, and in the author's Synthetic Air Chart is called zero ventilation. This chart also takes into account wet and dry bulb temperatures, dust particles, bacteria, odors and other injurious substances. The chart and method for using it are not suitable for abstracting. The cubic feet of air to be supplied per person per minute in a classroom is as follows: without humidification and recirculation, 30; with humidification and recirculation 5 to 10. Outside air in city buildings often contain two million particles of dust per cubic foot. A good air washer should eliminate 80 to 90 per cent of this. A. P. SY

Science and Industry. MARTIN H. FISCHER. *Ind. Eng. Chem.*, News Ed., **3**, No. 2, 5–6 (Jan. 20, 1925).—A discussion of the purpose of the Research Laboratory of the Tanners' Council which has been established at the Univ. of Cincinnati. This co-operative agreement marks a distinct step forward; all results of research are to be freely published. F. also presents the case of the "practical" shopman and the scientist with real university training behind him. The former is prepared to deliver quick results, just as is a sleight-of-hand performer. And because industry is faced with problems of the hour it is willing to pay for immediate action. Everything is satisfactory as long as the cogs run smoothly, "but who will help us when fuel changes, when raw materials give out, when new needs arise and the very ground socially or economically shifts under our feet?" When faced by the failure of old rules or confronted by changed conditions shop men and practical men "have a way of withering and only one brand of vegetable can stand the new climate, and that is the fast-growing and quick-maturing hardy winter wheat of our universities. . . . Practical men fail because what they operate with is essentially a bag of tricks. . . . The university man . . . carries a much smaller sack but it contains a valuable coin, which, for lack of a better name, I shall call 'method.' " B.

Answer to Cross-Word Puzzle in January Issue of This Journal

ERITREA ISOTOPE
ER TNT KOH DI
DOT HO DALTON
SUN HYDROXIDE RCP
C POLE X NEON H
UTAH S I E ALBA
IS R D I IE
UO SPONTANEOUS CL
MN D T N KA
B PB F I B CA K
E TRI U O L ICL E
RD DISINFECT AS
ALKALI ACETIC
R OH SC E
KAOLIN HELIUM

Local Activities and Opportunities

National Research Fellowships. The National Research Council has been entrusted with an appropriation of $125,000 by the Rockefeller Foundation for the coming year for the purpose of promoting fundamental research by the way of Fellowships in physics, chemistry and mathematics. This research is to be carried on principally in educational institutions of the United States, and the fellowships are to be awarded to American citizens who have had training equivalent to that represented by a Doctor's degree. The minimum stipend is $1800 for the first year. For application blanks and any details write W. E. Tisdale, National Research Council, Washington, D. C.

Princeton University. General A. A. Fries, Chief of Chemical Warfare Service, lectured before the Chemical Society, Thursday evening January 15.

Dr. Hugh Scott Taylor, Professor of Physical Chemistry, who has been in Europe since August, will resume his work at Princeton in February.

Professor A. W. C. Menzies has been granted leave of absence for the second half of the year. He and his family are planning to sail for Scotland.

By invitation, Dr. Charles P. Smyth read a paper on "Electric Moments," at the recent meeting of the A. A. A. S., in Washington.

New England Association of Chemistry Teachers. Two meetings of the Association have been held this school year. The annual meeting was held at Tufts College, Nov. 15th, and another was held at New London, Conn., Dec. 6th. Both of these meetings were well attended by secondary school people and college professors. As usual this association has attempted to correlate the work of its members so that both groups of teachers will find the meetings of value and interest.

The last meeting was held Feb. 14th at Boston English High School under the direction of the Central Division of the Association with Mr. Shipley Ricker, Woburn High School, chairman. The following program was given:

9.30 Executive Committee meeting.

10.00 "Models Used in Teaching Organic Chemistry," Prof. A. L. Pouleur, Wheaton College.

10.40 "Some Experiments with Nitrates," Mr. Charles H. Stone, English High School.

11.20 "Some Applications of Chemistry Applied to the Textile Industry," Prof. L. A. Olney, Lowell Tech.

12.00 Lunch.

1.15 Business Meeting:

(*a*) Committee reports.

(*b*) Election of New Members.

2.00 Motion picture, "The Fountain of Youth."

Science Association. The fourth annual meeting of the Science Section of the Association of Colleges and Preparatory Schools of the Middle Atlantic States and Maryland was held in Corcoran Hall, George Washington University, Washington, D. C., on November 29. Mr. H. M. Snyder, of Wilmington High School, Vice-President of the Section, acted as chairman. Over one hundred members were present.

General Amos A. Fries, Chief of the Chemical Warfare Service, U. S. Army, presented the main address of the meeting on the subject: "Chemistry in Our National Life." General Fries not only discussed the part chemistry had played during the war, but also dealt at some length with its applications in every-day life, in industries, in agriculture and in medicine.

Other papers were given: Mr. Leighton K. Smith, of the Chemistry Department, Wilmington High School, spoke on "Science Tests—The New Type vs. the Old Type;" Dr. E. A. Eckhardt, Physicist, Bureau of Standards, spoke on "The Teacher's Relation to Research;" and Miss Quaesita C. Drake, Professor of Chemistry, Women's College, University of Delaware, spoke on "A College Course for Students Who Have Had High School Chemistry."

The following were elected officers of the Section for the year 1924–1925: *President*, W. B. Meldrum, Haverford College, Haverford, Pa.; *Vice-President*, W. J. Hancock, Erasmus Hall High School, Brooklyn, N. Y.; *Secretary-Treasurer*, Elizabeth W. Towle, The Baldwin School, Bryn Mawr, Pa.; *Councillors*, Helen K. Eimet, William Penn High School, Philadelphia, Pa.; Earl R. Glenn, Lincoln School, N. Y. City; F. M. Comfort, Wilmington High School, Wilmington, Del.

Wisconsin Chemistry Teachers' Association. Many Badger high school teachers of chemistry have recently joined the newly formed association of chemistry teachers. The new association intends to affiliate with the Division of Chemical Education of the American Chemical Society. Its purpose is to bring about a high degree of coöperation between the teachers of chemistry in the high schools, normal schools, and colleges, and the State University. The programs are planned to include visits to various industrial chemical plants in and around Milwaukee.

Harvard University. R. J. Harighurst holds a National Research Fellowship in physics where

he is doing work on the X-ray. Dr. Harighurst received his Ph.D. from Ohio State University.

University of Utah. A meeting of the Northwestern Utah Section of the American Chemical Society was held in the chemistry lecture room at the University of Utah December 18th. Dr. Orin Tugman, of the Physics Department of the University of Utah, gave a very interesting talk on "Sound Measurements." Dr. Tugman spent his sabbatical year at the Riverbank Laboratories at Geneva, Illinois, and during that time worked on methods of measuring sound intensities. Mr. George P. Unseld, Head of the Physics Department of the West Side High School, gave an excellent discussion on the topic "Heat."

At the previous meeting of this section, there was a discussion on the advisability of attempting an organization of the chemistry teachers of Utah. The consensus of opinion seemed to be that such an organization would have to be a part of the local section to be successful. There is no lack of enthusiasm on the part of the teachers of this state, but distances are so great it is very hard to get together It was agreed that at least one meeting of this section would be devoted each year to papers on teaching chemistry.

Chicago Association of Chemistry Teachers. At the second meeting, Dec. 19, Mr. B. F. Ball, of Deerfield-Shields High School discussed the relative importance of "Subject Matter" and "Chemical Principles." Emphasis on subject matter leads the pupil to memorize—not a worthy aim when such data is conveniently carried in hand-books. Emphasis on principles leads pupils to think about the subject matter and generalize. General principles learned without the data of subject matter are usually memorized and are not practical because the pupil rarely applies them. Too often the pupil only encounters the subject matter and does not develop the generalities. The weights of a liter of various gases should not be memorized. If the vapor density relation to unit volume of hydrogen is known then volume weights of any gases are readily calculated. With the increase of subject matter the first year course in chemistry tends to become a "tourist course." There must be time to develop principles by review and fix them in mind by appropriate drill. Manipulation in the laboratory is valuable in itself but will not justify the use of time for it unless facts are collected as a basis for the establishment of principles.

University of Minnesota. The Third National Colloid Symposium will meet at the University of Minnesota, Minneapolis, Minnesota, on June 17, 18 and 19, 1925. Plans as already formulated will offer to chemists an exceedingly attractive program. Professor Herbert Freundlich, of the Kaiser Wilhelm Institute, Berlin, is to be the invited guest and principle speaker at the Symposium. This alone should insure a large attendance at the meetings. Since Prof. Freundlich's chief interest is in adsorption, the program will probably stress that phase of colloid chemistry.

Extensive plans are being made for the entertainment of visiting chemists. It is expected that a complimentary drive through the Twin Cities followed by a dinner on the University campus will be given on the opening day. Moving pictures of colloid phenomena are to be given the second evening. Special features are planned for the entertainment of any women who may attend. Additional information may be obtained by writing Prof. R. A. Gortner, Chairman of the general arrangements committee, University Farm, St. Paul, Minnesota.

University of Montana. The Chemistry Club at the University of Montana recently presented a four reel film on "The Manufacture of Armco Ingot Iron." This is only one of the many efforts of this active club in trying to show the people in Montana the use of chemistry.

Nebraska Wesleyan University. Professor Howard A. Durham of Nebraska Wesleyan University and a member of the Nebraska Section of the American Chemical Society was elected president of the physical science section of the Nebraska State Teachers' Association at its annual meeting the week of December 29. Professor Durham is the third chemist to be president of this section during the past three years.

University of Nebraska. Dr. Manne Siegbohn of Upsala, Sweden, gave two lectures before joint sessions of the Nebraska section of the A. C. S. and the University of Nebraska Physics Colloquium, January 21 and 22, 1925. His subjects were: "X-Ray Spectra and Atomic Structure," and "Exact Determination of Wave Length in X-Ray Spectra."

Nebraska Academy of Science. The Nebraska Academy of Science executive committee has appointed Dr. M. J. Blish, former president of the Nebraska Section of the American Chemical Society, chairman of the chemical section of the Academy for its 1925 meeting. That means one section meeting, at least, will be devoted exclusively to chemistry. Plans are also on foot to have one general meeting of the sessions devoted to the interests of science teachers. The Academy will meet in Lincoln this year.

West Virginia Teacher's Association. The second meeting of the West Virginia Teacher's Association was held at the University of West Virginia, Morgantown, Va. The correlation of high school and college chemistry and the organization of chemistry teachers, were the two principle problems discussed at the session. The sentiment was in favor of urging all chemistry teachers in the state to become members of the association. For general encouragement it was agreed to keep dues at a low figure, namely $.50 per year.

The teachers present at the meeting were emphatic in recommending that teachers of chemistry should take the JOURNAL OF CHEMICAL

EDUCATION, which is being published under the direction of the Division of Chemical Education of the American Chemical Society. The price of the Journal is $2.00 per year. Two dollars and twenty-five ($2.25) was set as the combined cost of the JOURNAL OF CHEMICAL EDUCATION and membership in the West Virginia Chemistry Teacher's Association. For teachers who are not members of the A. C. S. and who may wish to be affiliated with the Division of Chemical Education of the A. C. S. and at the same time take the Journal and belong to the West Virginia Chemistry Teacher's Association, the cost is $3.25.

California Chemistry Teachers. The California Section of the A. C. S. has taken steps leading to the bringing of all of the teachers of chemistry in the high schools, junior colleges, and higher institutions of learning, into affiliation with the Local Section of the A. C. S., either as associate or full membership. The Section has further adopted a plan for promoting interest in chemistry among high school students in which competitive examinations are held in May of each year among teams as well as individual representatives from high schools in the area over which the Section has jurisdiction. Prizes are awarded to the best team and to the best individual record. A similar plan has been in operation in the other two Sections organized in California, thus bringing all of the high schools of the State under competition of this character.

Leland Stanford University. Prof. R. E. Swain, of the Department of Chemistry of Stanford University, addressed the Science Section of the California State Teachers' Association in San Francisco, December 16, 1924, on the subject "The Articulation of High School and College Chemistry."

Prof. Edward C. Franklin, of the Department of Chemistry of Stanford University, has been awarded the Nichols Medal for having presented the best paper of the year 1924, published in the journals of the American Chemical Society. The medal will be presented at the Chemists Club, New York City on March 6th.

Prof. Alexander Findlay, of Aberdeen University, Scotland, widely known for his research work in Chemistry, and as the author of a number of important books, is spending the last three quarters of this academic year at Stanford University as Acting Professor of Chemistry.

University of Utah. Dr. Walter D. Bonner, Head of the Chemistry Department of the University of Utah, and also Chairman of the local section of the American Chemical Society had rather a serious accident when he was accidently gassed with chlorine. The accident was caused by a leaking valve on a chlorine tank and a faulty gas mask. He was only confined to his home for a few days.

West Virginia University. Provost C. K. Edmonds met all the Johns Hopkins Alumnae of the West Virginia University and vicinity at a recent gathering at Morgantown where Dr. Edmonds delivered a very inspiring talk.

University of Nevada. A fellowship is offered by the University of Nevada in chemistry for 1925–26 with a salary of $600. The fellow will devote not more than half time (12½ hours per week) to instruction in the laboratory. The remaining time will be expected to be devoted to graduate study and research. This fellowship is open to students who have had thorough undergraduate training in chemistry and who hold a bachelor's degree from a college or university of recognized standing. Applicants should communicate with Professor M. Adams, head of the department of chemistry.

Recent Books

Grundzüge der Kolloidlehre. HERBERT FREUNDLICH. 157 pages. Akademische Verlagsgesellschaft. M.b.h. Leipzig, 1924.

When I was asked to review this book for THIS JOURNAL I accepted with the feeling that it was an added task but one which should be performed. Instead of a task, however, the reading proved to be a real pleasure.

Professor Freundlich states in the preface that he has been intending for a long time to condense his "Kapillarchemie" into an introduction to colloid chemistry without the use of mathematical formulae and extensive tables or illustrations and that he believes such a work would assist those working in the fields of medicine or the industries. The present volume represents such an attempt. *It is a condensed and simplified "Kapillarchemie"* brought up to date by numerous references to recent investigations. This being the case it is perhaps superfluous to add any further comment.

The phenomena of surfaces, interfaces, and adsorption are discussed in the first 70 pages. This discussion is unusually clear and to the point. Emphasis is laid on the theories of Harkins and Langmuir as showing orientation in surface or interfacial films and adsorption is ex-

plained as being probably due to the secondary valences or unbalanced attractions of the atoms on the face of the crystal lattice. A discussion of surface energy and crystal growth follows the section on surfaces and interfaces and the physico-chemical phenomena are completed by a discussion of Brownian movement and kinetic energy.

The remainder of the book is devoted to a consideration of the properties of disperse systems utilizing and emphasizing the importance of the principles discussed in the earlier part. Forty-two pages are devoted to sols, 13 pages to gels, and the remainder of the book to smokes, foams, and disperse systems containing more than two phases.

As an introductory text I can find nothing in the book worthy of criticism and much to commend. It is in my opinion the best book of its size which has yet appeared covering this field of chemistry. It could be used to advantage as a textbook in an introductory course in colloid chemistry where the students have a reading knowledge of German. The German construction is not involved and the vocabulary does not contain many unusual (from the chemical standpoint) terms. There, however, is a rhythm and a literary style which makes it delightful reading. I also recommend it to those students who are reading German in preparation for the language requirements for the higher degrees.

ROSS AIKEN GORTNER

The "Chemical Age" Chemical Dictionary: Chemical Terms. D. Van Nostrand Company, Eight Warren Street, New York City, 1924. Price $4.50.

This book is designed as the forerunner of a series of chemical dictionaries to be brought out by the publishers of The Chemical Age of London. It is a compilation of nearly 3000 general terms, used in organic, physical, inorganic, analytical, and biological chemistry, particularly in the first two subjects. But few names of specific substances are defined, these presumably being left for subsequent volumes. One of the most valuable features of the book is the extensive list of types of organic compounds and reactions. This list is more complete than that for any of the other branches of chemistry; yet it is not comprehensive enough "to meet the needs of all those who have to consult not only original papers or their abstracts but other forms of literature as represented by reviews and modern textbooks." Definitions are usually clear and well illustrated by equations, structural formulas or other examples.

As a rule care has been used in the selection of terms. There are, however, a number of inconsistencies both in the choice of material and in the use of symbols. In the expression for the diffusion constant and in that for the ionic radius, for example, ρ has a different significance. Beryllates and zincates are listed alphabetically but not aluminates, selenates, tellurates, or tungstates. Molal, the Bohr atom, Kolbe's reaction, centrifuge and chromyl are among the other omissions in the alphabetical arrangement. Several errors have been made in definitions. *Anion*, for instance, is defined as "the positive ion furnished by an electrolyte;" *cations* as "the negative ions." These terms are used correctly under the heading of Electrolysis. Atomic number is incorrectly said to be *the total number of electrons in the atom.* "Friedel-Craft reaction" should be Friedel-Crafts' reaction. Evidently a typographical error was made in the mathematical statement of Graham's law. Many of these inconsistencies and errors might have been eliminated by proper editorial supervision—a suggestion for subsequent volumes.

All things considered, the good points far outweigh the faults. The book should prove to be useful as a dictionary of general chemical terms.

M. C. SNEED

Introduction to Organic Research. By E. EMMET REID, Ph.D. Professor of Organic Chemistry. Johns Hopkins University. 6 × 9½. Cloth, 35 pp. $4.50.

Dr. Reid's book is really broader than its title warrants one to expect. Only seven of its eighteen chapters are devoted to organic chemistry. It is rather a general survey of the field of chemical research with applications from the chemistry of the carbon compounds.

To the teacher of high school chemistry, this book ought to serve as an inviting introduction into the field of research. It ought to give the student about to undertake post graduate work in chemistry, some idea of what is before him. To the director of investigative work, it gives a definite reference to collected material for fixing in the mind of the young experimentalist the ideals and methods of research together with a valuable collection of information as to the journal literature of chemistry and the important secondary sources. It also makes a number of valuable suggestions for arranging permanent records of experimental work. The large number of quotations from authorities in modern scientific research adds much general interest to the book.

The subject matter is not presented in any striking or novel way, but is rather a painstaking accumulation of material not readily available. A large number of footnote references invite one to further study.

Chapters dealing with organic chemistry are more for the particular investigator in that field, and are full of valuable suggestions. But the work can be read with profit by any one who desires to know more of the method for scientific investigation.

ARTHUR M. PARDEE